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ABSTRACT

The second of three volumes of papers presented at the 1979 ADCIS convention, this collection includes 37 papers presented to four special interest groups--computer based training, deaf education, elementary/secondary education/junior colleges, and health education. The eight papers on computer based training describe computer graphics, computer supported graphics, and simulations in military training; CBI in flight instruction; a new self-paced course on BASIC language programming; and CMI in vocational education. The ten papers scheduled for the educators of the deaf are concerned not only with projects for teaching language/communication and writing skills to the deaf, but with access to CAI for the blind and visually handicapped, and programs in special education. Projects described for the elementary/secondary/junior colleges group focused on curriculum development, classroom applications, CAI in special education, attitudes of high school students toward the computer, CMI in a large school system, a program for functionally illiterate adults, and a survey course in computer science in a community college. The health interest group heard nine papers on various aspects of medical training using CAI, simulations, computerized tests, and a set of computer self-evaluation units designed to accompany a physiology course. Some papers are illustrated with flow charts and diagrams and/or include brief bibliographies. (RAO)

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ED175448

MISSION OF THE FUTURE

PROCEEDINGS OF THE ANNUAL CONVENTION

OF THE

ASSOCIATION FOR THE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS

VOLUME II

A. SPECIAL INTEREST GROUP FOR COMPUTER BASED TRAINING
B. SPECIAL INTEREST GROUP FOR EDUCATORS OF THE DEAF
C. ELEMENTARY/SECONDARY/JUNIOR COLLEGE INTEREST GROUP
D. HEALTH INTEREST GROUP

1979

ISLANDIA HYATT HOUSE

SAN DIEGO, CALIFORNIA

FEBRUARY 27 TO MARCH 1

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IR007615

VOLUME II: SPECIAL INTEREST GROUP SESSION PAPERS

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Dynamic Military Engagements Through Computer Supported Graphics

W. M. Darden and S. G. Parrish
U. S. Naval Academy
Annapolis, Maryland 21402

Since February 1977, we have developed and refined the concept of Dynamic Military Engagements through Computer Supported Graphics. In this concept, the computer performs the mechanical aspects of the project by acting as a multi-media blackboard which presents computer-generated maps of troop deployment; actual slides of the battlefield, as it was then and as it is now; and illustrations of the principal generals, commanders, and weapons of the day. This method of using the computer is unique in the teaching of history.

The objectives of the project are:

a. To present military and naval campaigns and battles through Dynamic Computer Supported Graphics.

b. To be able to show graphically the possible outcome of a battle, given different developments during the battle than those which actually occurred ("yes, but what if...").

c. To allow the student to make military decisions based on changing situations.

These objectives are to be achieved through the use of interactive computer simulation of naval and land warfare, which will offer any student a practical foundation in military problems. These problems may involve national policy, military organization, strategic decision, logistics, tactics, command relationship, or leadership. Two basic concepts will be emphasized in this project:

a. the influence of technological, economic, social and political change upon evolving military and naval policy and operations.

b. the constant factors which persist throughout naval and military history, and which promise to remain constant despite dramatic changes in technology or social order throughout the world.

The hardware used to present the simulations is a gas plasma display terminal and the Techtronix terminal. With the plasma terminal, we are able to use microfiche illustrations of actual battle scenes, portraits of the leaders of the battle, and present-day pictures of the original battlefield. Illustrations numbered 1 through 10 are examples of what can be displayed on the terminals.

Through the Dynamic Computer Military Engagements, the student can take the place of any commander and fight the battle as it was fought, or, in our plans for the future, make changes in strategic and tactical situations and see what the results would have been. Our plans call for the instructor being able to change the parameters of the campaign or battle and then watch the students make immediate decisions based on their knowledge of existing conditions.

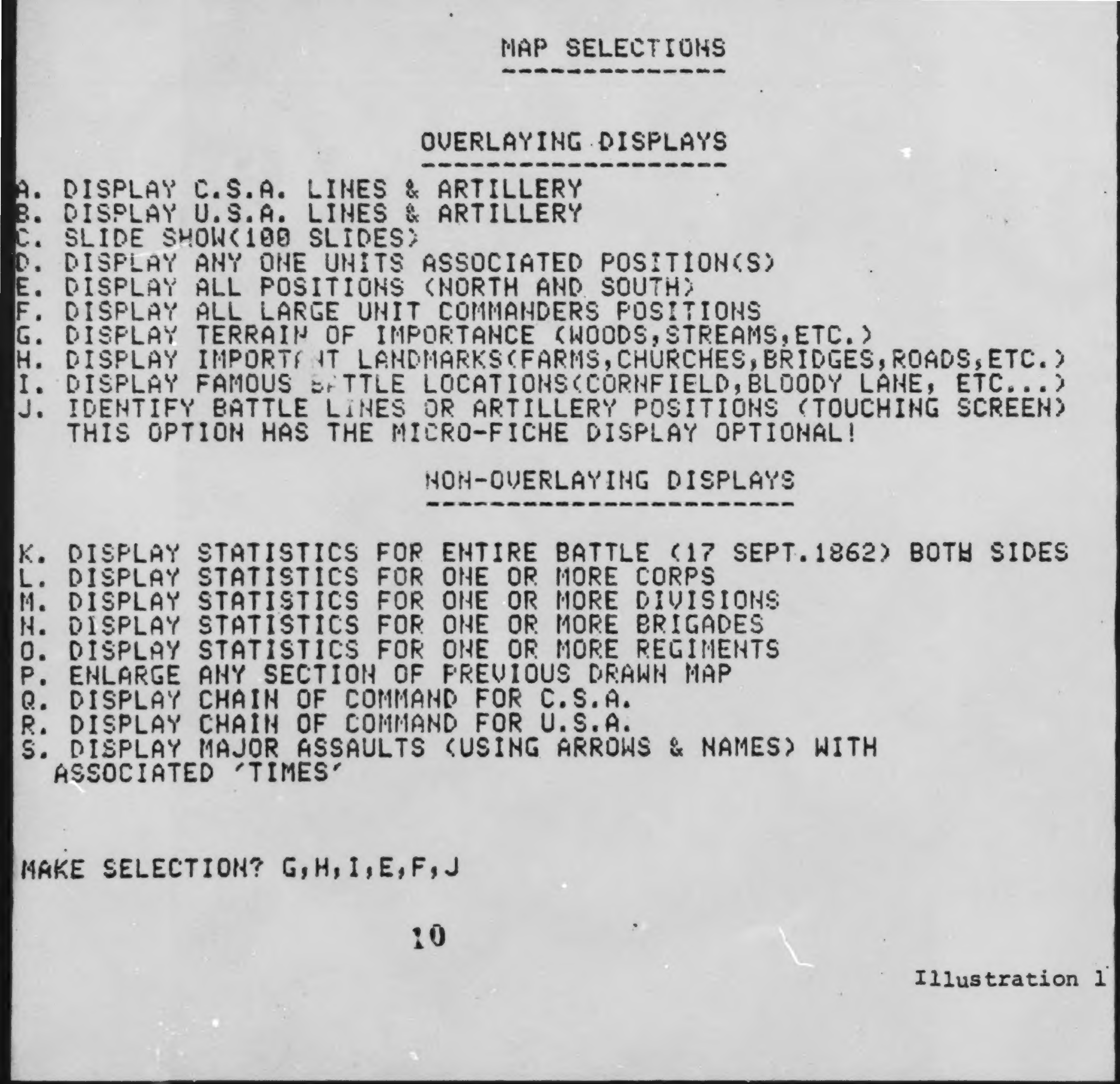
In land campaigns and battles, a topographical chart can be made to appear on the scope, detailing the terrain over which the action took place. One of the most important aspects of land warfare is terrain, and an excellent way to teach the importance of terrain is to have the student trace the movement of the forces on a topographical chart of the actual combat area.

Since the start of this project, we have been able to put on line two World War II naval actions, (Battle of Tassafaronga, Battle of Savo Island), Battle of Minorca, Battle of the Virginia Capes, Battle of Lake Erie and, to the Computer, the rather complicated Battle of Antietam. Being put on line now are the Battles of Chancellorsville, Leuthen and Austerlitz. Most of these battles have been used in class instruction and are excellent teaching tools. It is as much a revelation to watch a fledgling engineer use a familiar tool, the computer in learning a subject which is unfamiliar to him, as it is to watch a neophyte historian in his humanistic studies use the engineer's tool. Both groups of students enjoy learning by this unique method.

The battles of the War of Northern Aggression may be used also by the rather sophisticated researcher. The maps of Antietam that are projected by the terminals are those drawn by the CArmen Commission, set up by the U.S. Congress to recall the details of the battle and these are by far the most accurate to be found. The Order of Battle for both Union and Confederate forces is taken from the War of Rebellion, The Official Records of the Union and Confederate Armies. The casualty figures are from Livermore, Numbers and Losses in the Civil War, 1861-1865, as well as the above mentioned sources. Many other authoritarian sources were consulted as well.

The research for the naval battles for World War II was done in official records, ship's logs, task force commander's reports, etc., as well as S. E. Morison's History of United States Naval Operations in World War II. Here also many more authoritarian sources were checked. Not only are casualty figures available but also you may be given the number of rounds fired by the guns of each United States ship as well as the number of torpedoes fired by each ship.

Dynamic Computer Military Engagements allows the computer to act as official records, an encyclopedia, a cartographer, and an eye witness to any battle or campaign. All of this is available to the instructor at the touch of a button!



```
                        MAP SELECTIONS
                        --------------

                     OVERLAYING DISPLAYS
                     -------------------
A. DISPLAY C.S.A. LINES & ARTILLERY
B. DISPLAY U.S.A. LINES & ARTILLERY
C. SLIDE SHOW(100 SLIDES)
D. DISPLAY ANY ONE UNITS ASSOCIATED POSITION(S)
E. DISPLAY ALL POSITIONS (NORTH AND SOUTH)
F. DISPLAY ALL LARGE UNIT COMMANDERS POSITIONS
G. DISPLAY TERRAIN OF IMPORTANCE (WOODS,STREAMS,ETC.)
H. DISPLAY IMPORTANT LANDMARKS(FARMS,CHURCHES,BRIDGES,ROADS,ETC.)
I. DISPLAY FAMOUS BATTLE LOCATIONS(CORNFIELD,BLOODY LANE, ETC...)
J. IDENTIFY BATTLE LINES OR ARTILLERY POSITIONS (TOUCHING SCREEN)
   THIS OPTION HAS THE MICRO-FICHE DISPLAY OPTIONAL!

                     NON-OVERLAYING DISPLAYS
                     -----------------------

K. DISPLAY STATISTICS FOR ENTIRE BATTLE (17 SEPT.1862) BOTH SIDES
L. DISPLAY STATISTICS FOR ONE OR MORE CORPS
M. DISPLAY STATISTICS FOR ONE OR MORE DIVISIONS
N. DISPLAY STATISTICS FOR ONE OR MORE BRIGADES
O. DISPLAY STATISTICS FOR ONE OR MORE REGIMENTS
P. ENLARGE ANY SECTION OF PREVIOUS DRAWN MAP
Q. DISPLAY CHAIN OF COMMAND FOR C.S.A.
R. DISPLAY CHAIN OF COMMAND FOR U.S.A.
S. DISPLAY MAJOR ASSAULTS (USING ARROWS & NAMES) WITH
  ASSOCIATED 'TIMES'


MAKE SELECTION? G,H,I,E,F,J
```

Illustration 1

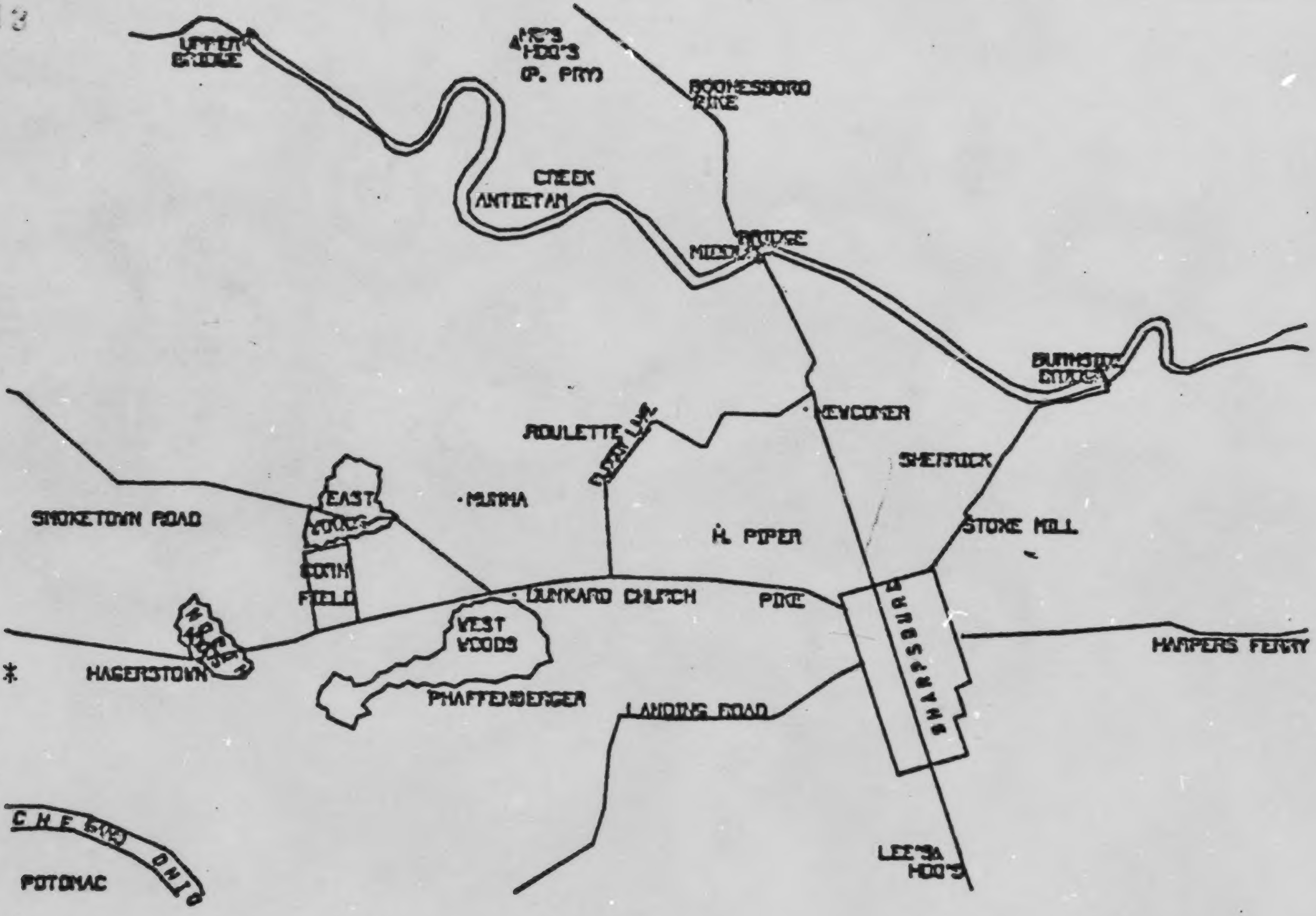
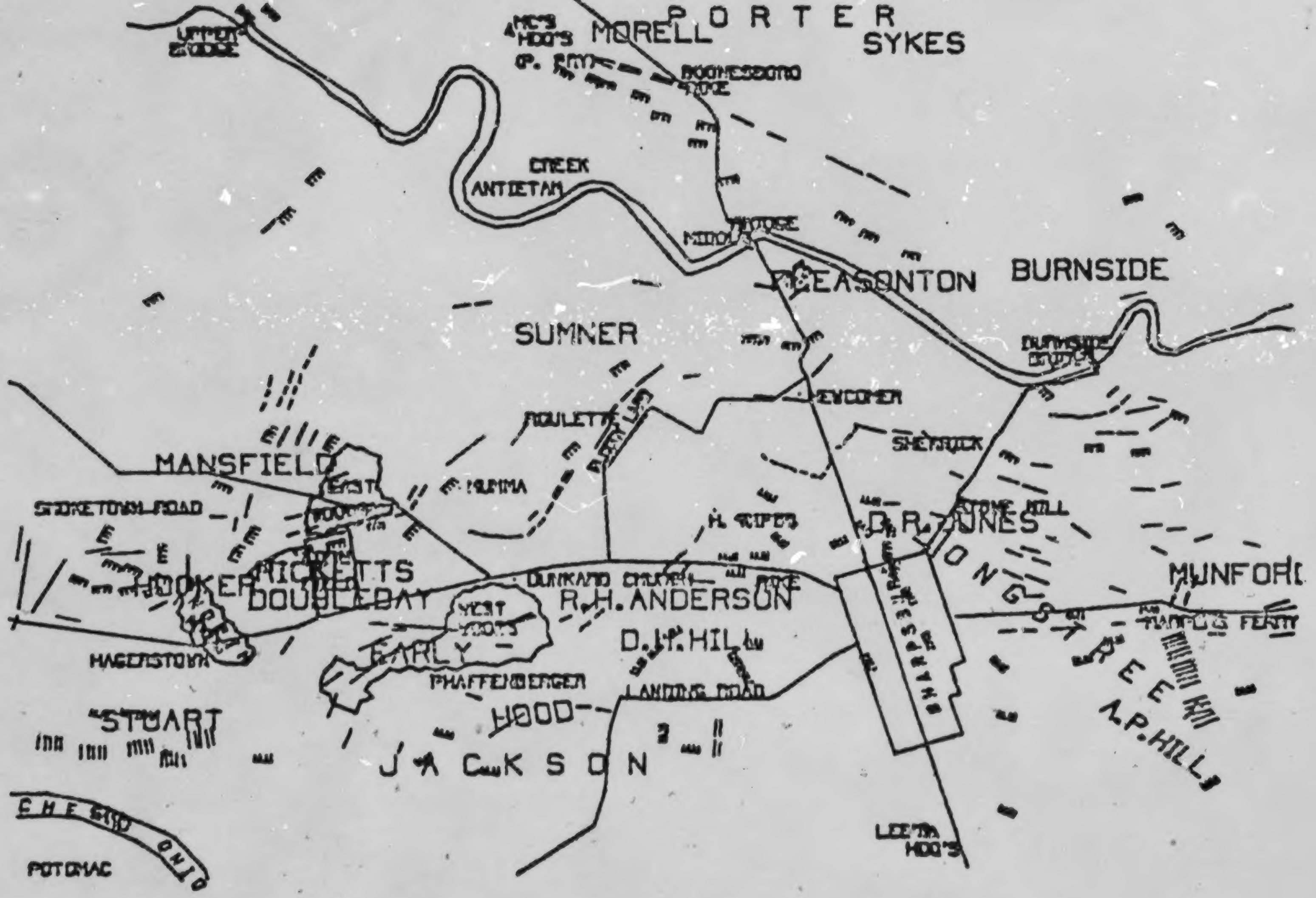

UPPER BRIDGE
McC'S HDQ'S (P. FRY)
BOONESBORO PIKE
CREEK
ANTIETAM
MIDDLE BRIDGE
BURNSIDE BRIDGE
NEWCOMER
ROULETTE
SUNKEN LANE
SHERRICK
EAST WOODS
MUMMA
SMOKETOWN ROAD
H. PIPER
STONE MILL
CORN FIELD
DUNKARD CHURCH
PIKE
SHARPSBURG
NORTH WOODS
WEST WOODS
HARPERS FERRY
HAGERSTOWN
PHAFFENBERGER
LANDING ROAD
LEE'S HDQ'S
C H E S(AP) OHIO
POTOMAC

Illustration 2

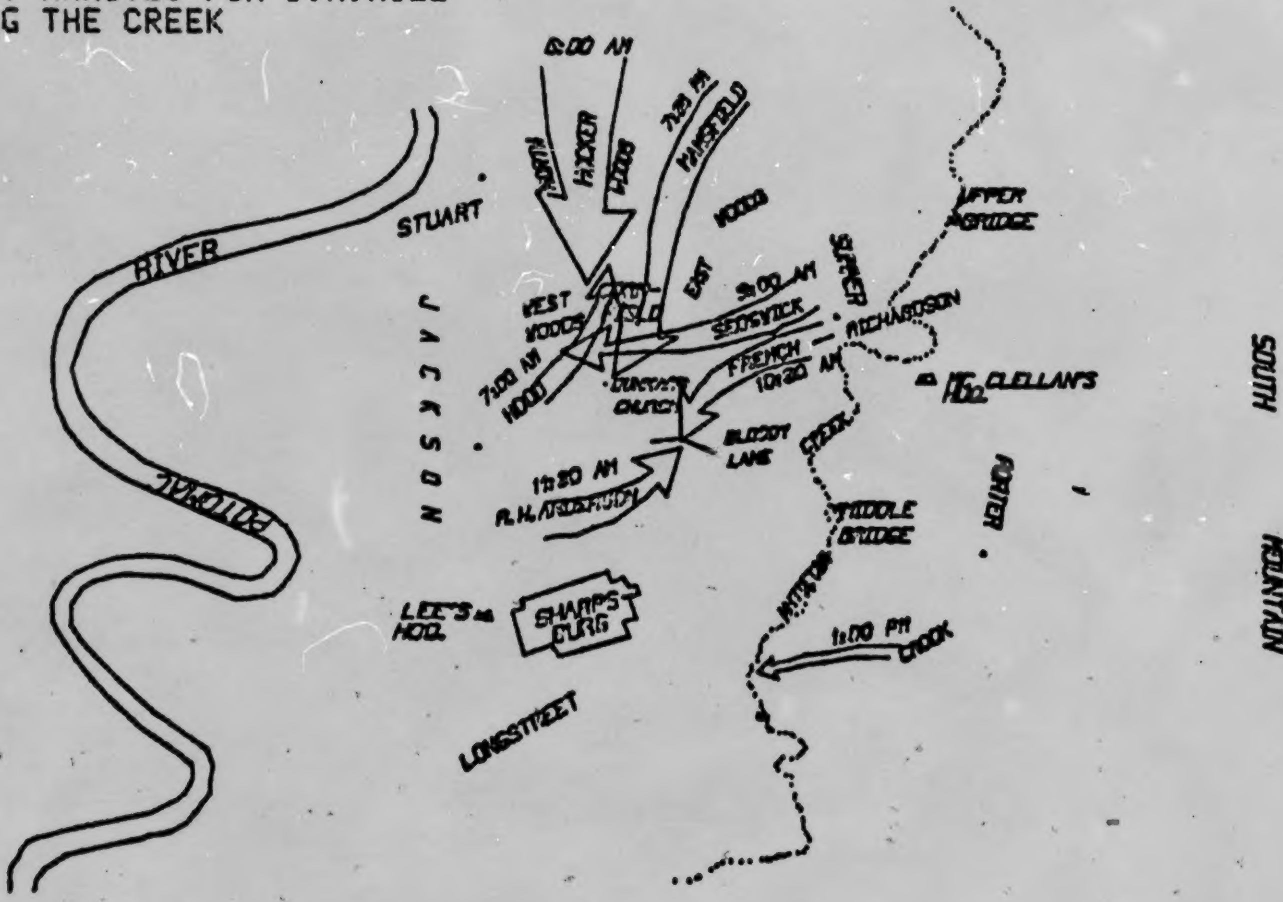

UPPER BRIDGE
MC'S HDQ'S
MORELL
PORTER
SYKES
BOONESBORO PIKE
CREEK
ANTIETAM
MIDDLE BRIDGE
PLEASONTON
BURNSIDE
SUMNER
BURNSIDE BRIDGE
NEWCOMER
ROULETTE
BLOODY LANE
SHERRICK
MANSFIELD
MUMMA
EAST WOODS
SMOKETOWN ROAD
H. PIPER
STONE HILL
D.R. JONES
HOOKER
RICKETTS
DOUBLEDAY
DUNKARD CHURCH
PIKE
R.H. ANDERSON
LONGSTREET
MUNFORD
FERRY
WEST WOODS
HAGERSTOWN
EARLY
D.H. HILL
PHAFFENBERGER
LANDING ROAD
SHARPSBURG
HOOD
STUART
JACKSON
A.P. HILL
LEE'S HDQ'S
CHES AND OHIO
POTOMAC

13

14

Illustration 3

FROM THE NORTH WOODS COMES DOUBLEDAY'S AND RICKETT'S DIVISIONS
FROM THE WEST WOODS - JACKSON LAUNCHES A DRIVING COUNTERATTACK!
SEEING HOOKER'S PLIGHT MORE MEN RUSHED FROM THE EAST WOODS
SUMNER DECIDES TO STRIKE IMMEDIATELY - AMBUSHED BY JACKSON
SUMNER'S MEN ATTACK D.H.HILL IN THE SUNKEN ROAD (BLOODY LANE)
SUPPORT ARRIVES FOR D.H.HILL
FORDING THE CREEK


6:00 AM
NORTH
HOOKER
WOODS
7:30 AM
MANSFIELD
STUART
EAST
WOODS
UPPER
BRIDGE
SUMNER
9:00 AM
SEDGWICK
RICHARDSON
WEST
WOODS
7:00 AM
HOOD
DUNKARD
CHURCH
FRENCH
10:30 AM
McCLELLAN'S
HDQ.
SOUTH
MOUNTAIN
RIVER
J A C K S O N
BLOODY
LANE
CREEK
11:30 AM
R.H. ANDERSON
POTOMAC
MIDDLE
BRIDGE
PORTER
ANTIETAM
LEE'S
HDQ.
SHARPSBURG
1:00 PM
CROOK
LONGSTREET

324

Illustration 4

SITUATION AT DAWN - 17 SEPT. 1862

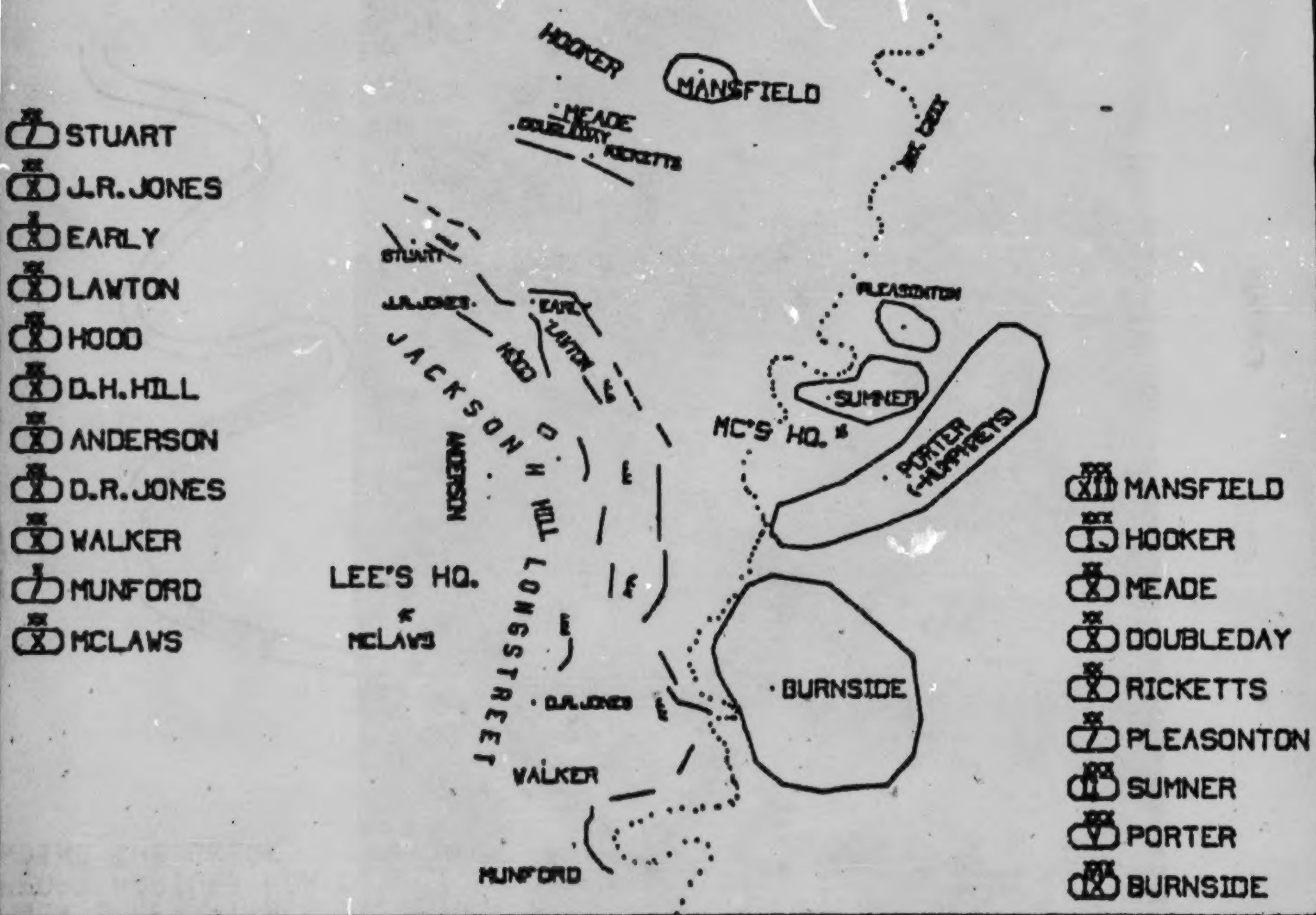
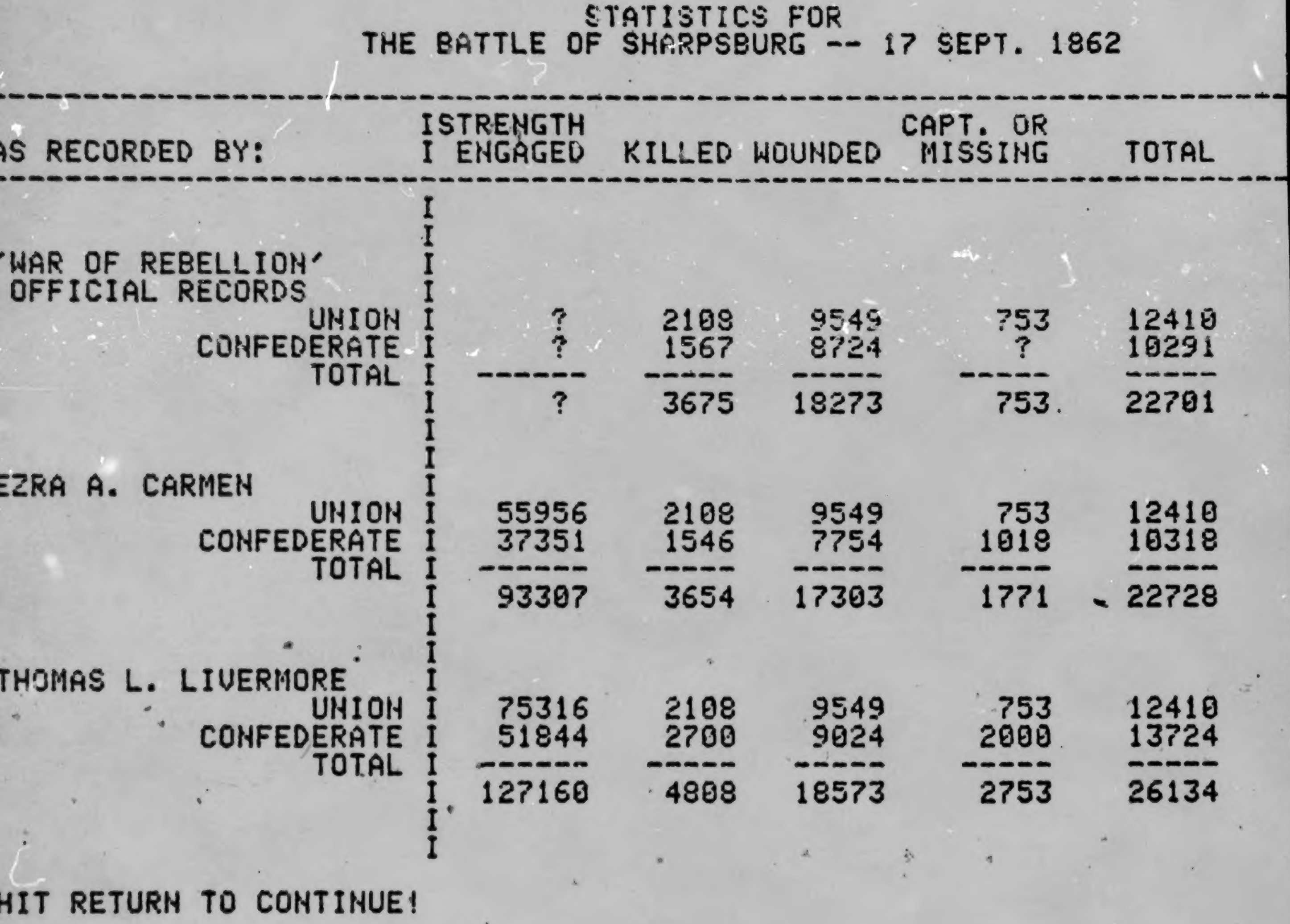
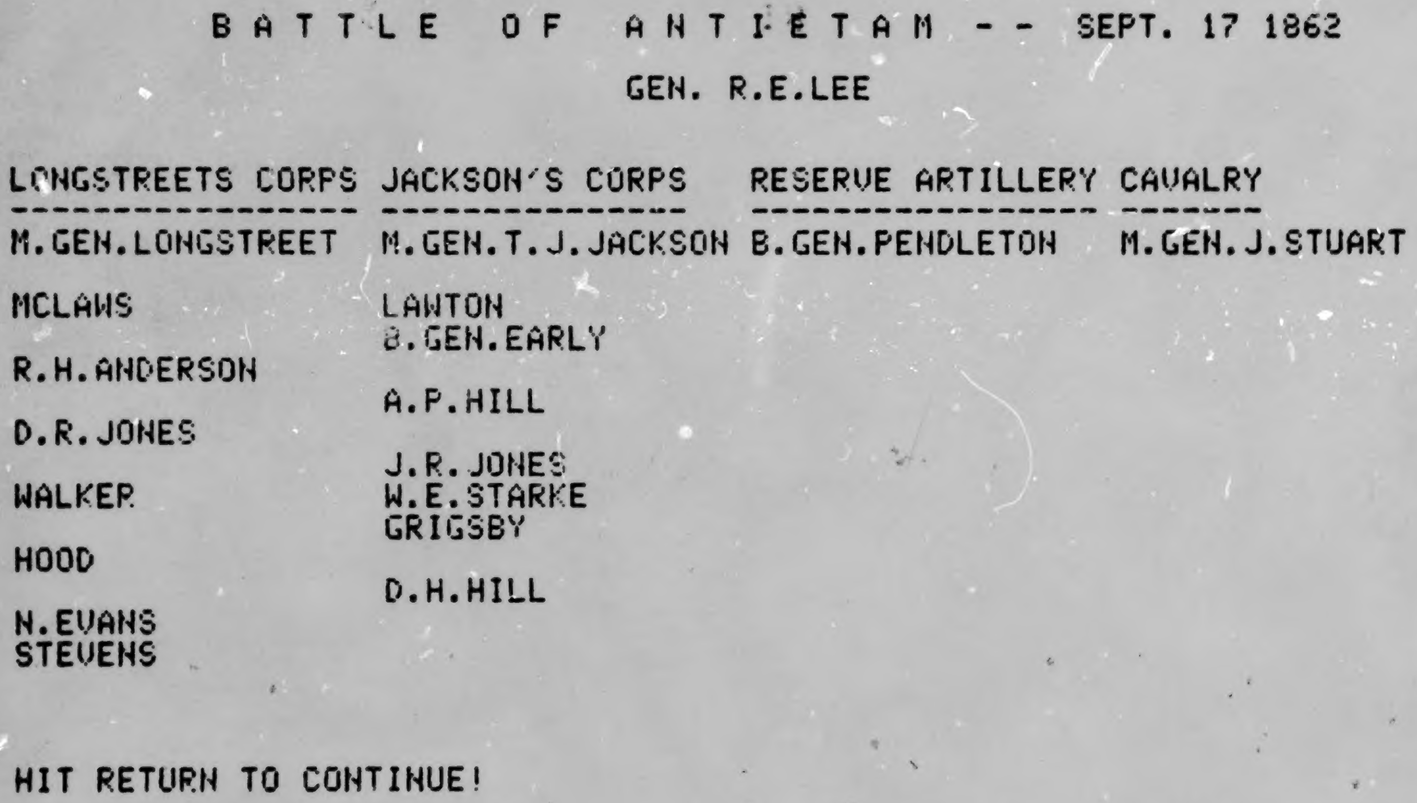

STUART
J.R.JONES
EARLY
LAWTON
HOOD
D.H.HILL
ANDERSON
D.R.JONES
WALKER
MUNFORD
MCLAWS
HOOKER
MANSFIELD
MEADE
DOUBLEDAY
RICKETTS
STUART
J.R.JONES
EARLY
LAWTON
HOOD
JACKSON
D.H.HILL
LONGSTREET
ANDERSON
LEE'S HQ.
MCLAWS
D.R.JONES
WALKER
MUNFORD
PLEASONTON
SUMNER
MC'S HQ.
PORTER
(-HUMPHREYS)
BURNSIDE
MANSFIELD
HOOKER
MEADE
DOUBLEDAY
RICKETTS
PLEASONTON
SUMNER
PORTER
BURNSIDE

Illustration 5



```
                           STATISTICS FOR
                THE BATTLE OF SHARPSBURG -- 17 SEPT. 1862
------------------------------------------------------------------------
                  ISTRENGTH                        CAPT. OR
AS RECORDED BY:   I ENGAGED  KILLED WOUNDED   MISSING     TOTAL
------------------------------------------------------------------------
                  I
                  I
'WAR OF REBELLION'I
 OFFICIAL RECORDS I
             UNION I      ?     2108    9549        753     12410
      CONFEDERATE I      ?     1567    8724          ?     10291
             TOTAL I ------   -----   -----      -----     -----
                  I      ?     3675   18273        753.    22701
                  I
                  I
EZRA A. CARMEN    I
             UNION I  55956     2108    9549        753     12410
      CONFEDERATE I  37351     1546    7754       1018     10318
             TOTAL I ------   -----   -----      -----     -----
                  I  93307     3654   17303       1771     22728
                  I
                  I
THOMAS L. LIVERMORE I
             UNION I  75316     2108    9549        753     12410
      CONFEDERATE I  51844     2700    9024       2000     13724
             TOTAL I ------   -----   -----      -----     -----
                  I 127160     4808   18573       2753     26134
                  I
                  I
HIT RETURN TO CONTINUE!
```

Illustration 6



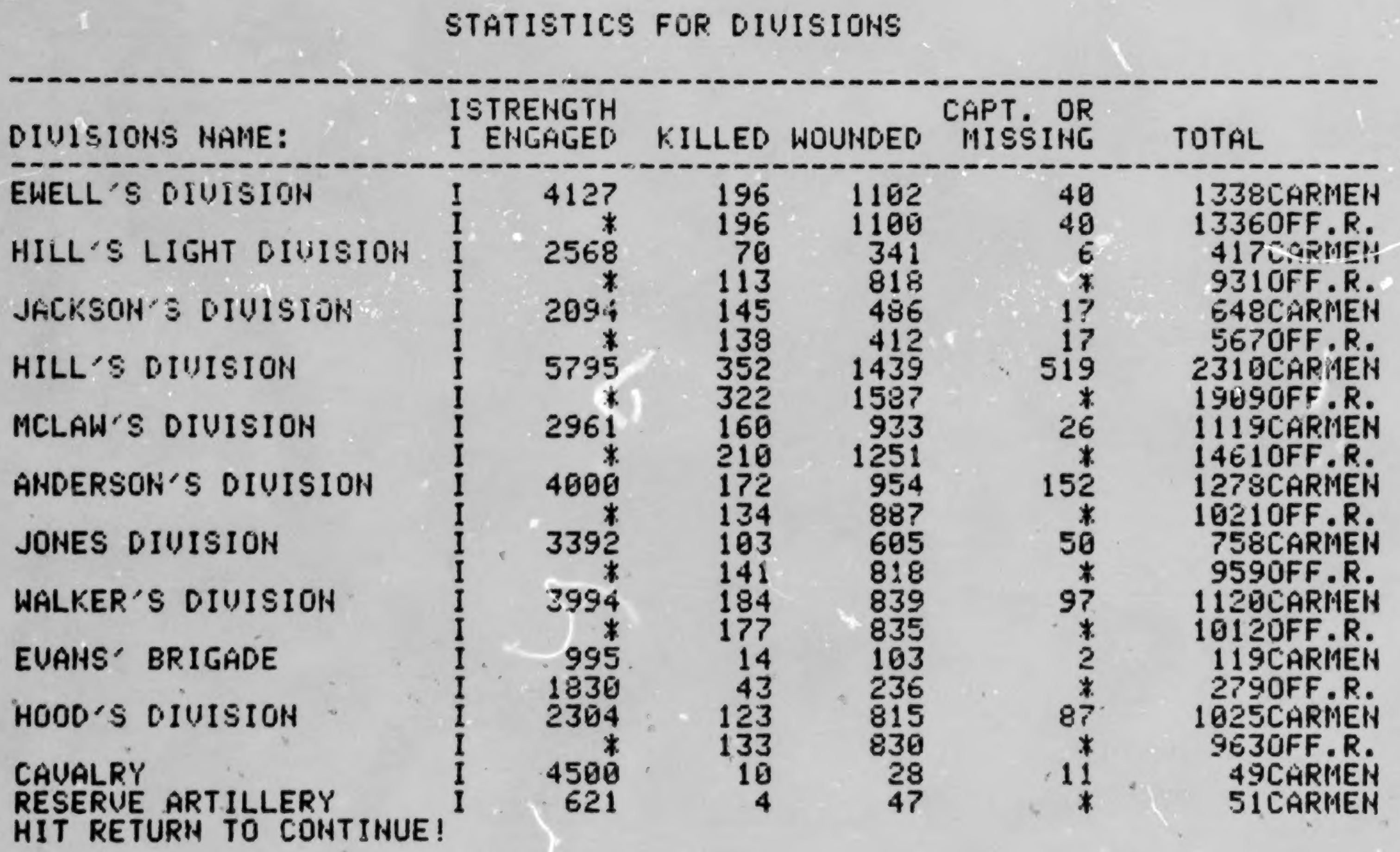
```
        B A T T L E   O F   A N T I E T A M  - -  SEPT. 17 1862
                         GEN. R.E.LEE

LONGSTREETS CORPS  JACKSON'S CORPS    RESERVE ARTILLERY CAVALRY
-----------------  ---------------    ----------------- -------
M.GEN.LONGSTREET   M.GEN.T.J.JACKSON B.GEN.PENDLETON   M.GEN.J.STUART

MCLAWS             LAWTON
                   B.GEN.EARLY
R.H.ANDERSON
                   A.P.HILL
D.R.JONES
                   J.R.JONES
WALKER             W.E.STARKE
                   GRIGSBY
HOOD
                   D.H.HILL
N.EVANS
STEVENS


HIT RETURN TO CONTINUE!
```

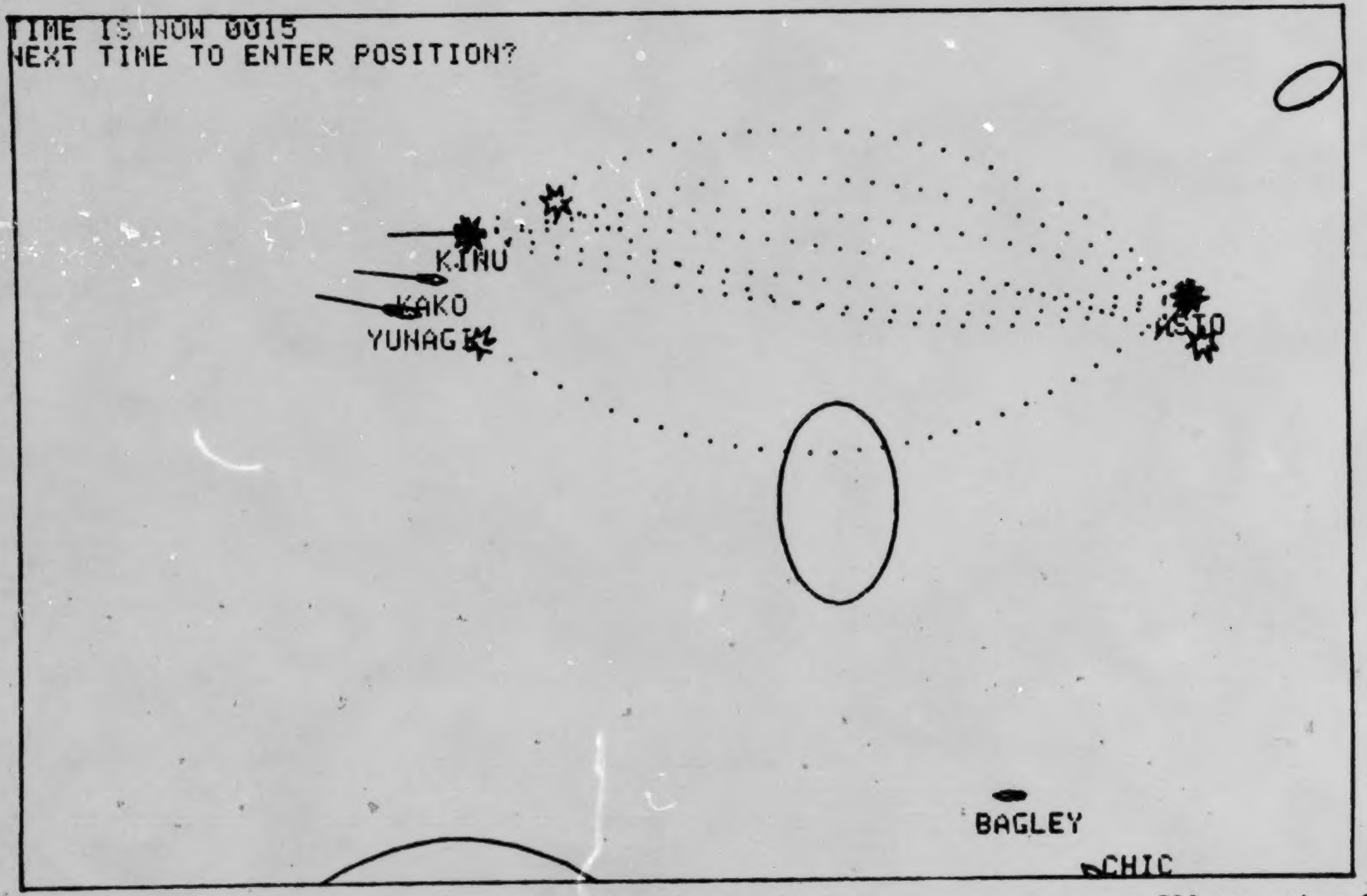
Illustration 7



```
                      STATISTICS FOR DIVISIONS

--------------------------------------------------------------------------------
                         ISTRENGTH                      CAPT. OR
DIVISIONS NAME:          I ENGAGED  KILLED WOUNDED  MISSING       TOTAL
--------------------------------------------------------------------------------
EWELL'S DIVISION         I    4127     196     1102        40     1338CARMEN
                         I       *     196     1100        40     1336OFF.R.
HILL'S LIGHT DIVISION    I    2568      70      341         6      417CARMEN
                         I       *     113      818         *      931OFF.R.
JACKSON'S DIVISION       I    2094     145      486        17      648CARMEN
                         I       *     138      412        17      567OFF.R.
HILL'S DIVISION          I    5795     352     1439       519     2310CARMEN
                         I       *     322     1587         *     1909OFF.R.
MCLAW'S DIVISION         I    2961     160      933        26     1119CARMEN
                         I       *     210     1251         *     1461OFF.R.
ANDERSON'S DIVISION      I    4000     172      954       152     1278CARMEN
                         I       *     134      887         *     1021OFF.R.
JONES DIVISION           I    3392     103      605        50      758CARMEN
                         I       *     141      818         *      959OFF.R.
WALKER'S DIVISION        I    3994     184      839        97     1120CARMEN
                         I       *     177      835         *     1012OFF.R.
EVANS' BRIGADE           I     995      14      103         2      119CARMEN
                         I    1830      43      236         *      279OFF.R.
HOOD'S DIVISION          I    2304     123      815        87     1025CARMEN
                         I       *     133      830         *      963OFF.R.
CAVALRY                  I    4500      10       28        11       49CARMEN
RESERVE ARTILLERY        I     621       4       47         *       51CARMEN
HIT RETURN TO CONTINUE!
```

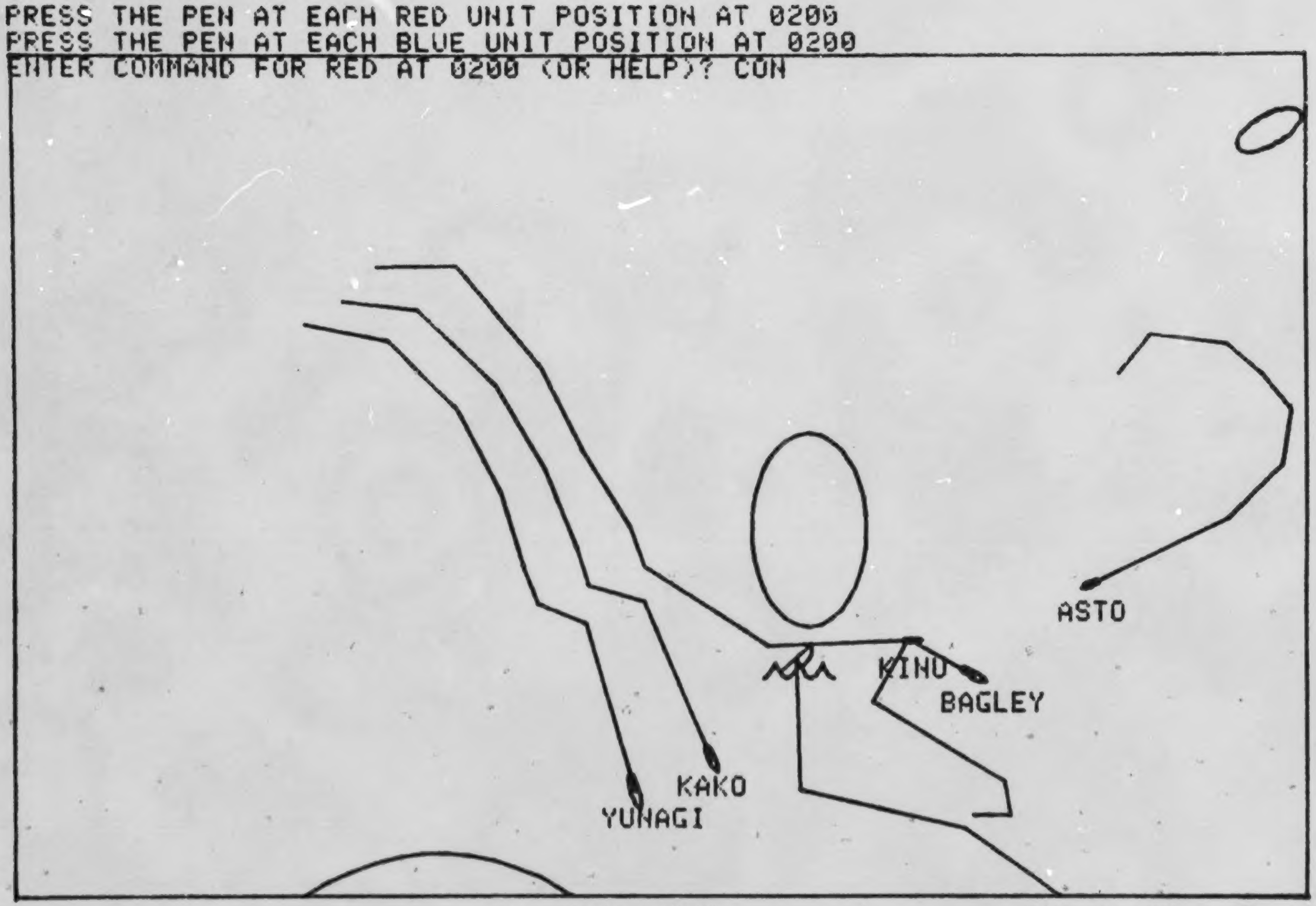
Illustration 8



```
TIME IS NOW 0015
NEXT TIME TO ENTER POSITION?
```

KINU
KAKO
YUNAGI
ASTO
BAGLEY
CHIC
SAVO ISLAND

Illustration 9



```
PRESS THE PEN AT EACH RED UNIT POSITION AT 0200
PRESS THE PEN AT EACH BLUE UNIT POSITION AT 0200
ENTER COMMAND FOR RED AT 0200 (OR HELP)? CON
```

ASTO
KINU
BAGLEY
KAKO
YUNAGI
SAVO ISLAND

Illustration 10

REQUIREMENTS ANALYSIS AND FEASIBILITY STUDY OF COMPUTER-BASED INSTRUCTION FOR THE FEDERAL AVIATION ADMINISTRATION DEPARTMENT OF TRANSPORTATION

BY

JOHN A. BUCK
DUANE R. BULLARD
THEODORE B. FAGAN

BACKGROUND AND HISTORY

The purpose of the Requirements Analysis and Feasibility Study is to review the total FAA training system including centralized technical training, field technical training, and centralized management and general training to determine if computer-based instruction (CBI) has general, cost-effective utility and, if so, in what form.

The study requires evaluation of the capabilities of various CBI systems; determination of FAA's future training requirements; determination of the cost/benefits of using a CBI system to support training accomplished by FAA; determination of the best CBI system for the FAA; and development of an implementation plan for conversion of training to CBI.

FAA initiated its first feasibility study of CBI at the FAA Academy in 1973. The study determined that the PLATO CBI system was more advanced than all other available CBI systems and was the system most appropriate for further study. Under the continuing study, a number of computer-assisted instruction (CAI) lessons have been developed which have achieved significant cost savings.

In June 1977, the Flight Standards Service of FAA indicated a requirement to train the flight inspection pilot/flight technician work force in automatic mode procedures as soon as possible. Review of this requirement by the FAA Office of Personnel and Training indicated that training time could be reduced significantly by use of CBI in the Flight Standards National Field Offices without increasing the associated costs or decreasing the quality of instruction.

In August 1977, the Air Traffic Service of FAA proposed a parallel project at the National Aviation Facilities Experimental Center in New Jersey to test the feasibility of use of CMI agencywide, beginning with courses on BAL and JOVIAL programming languages.

Both the Flight Standards and Air Traffic efforts being conducted on a test basis are included in the study and will be used as an evaluation test bed for the study.

STUDY ASSUMPTIONS

1. Use of CBI has been proven technically feasible.
2. Need for the present content of FAA training courses will not be included in the scope of the study.

STUDY REQUIREMENTS

In order to meet internal FAA requirements for development of automated data systems it was necessary to design a study plan which included periodic review and approval by management.

The approval process is illustrated in Figure 1. This process, known as the Data Systems Equipment and Services (DSES) systems, is used to handle administrative automated data processing procurements in the FAA. This paper describes efforts which are currently underway. The upper part of Figure 1 depicts the requirements analysis and feasibility study phases.

The overall study plan including the system proposal implementation and evaluation stages is detailed in Figure 2. Estimated times for accomplishment of tasks were developed and the PERT network was timed resulting in the chart displayed as Figure 3. Action began in this process in late April 1978.

Figure 1 **APPROVAL PROCESS**

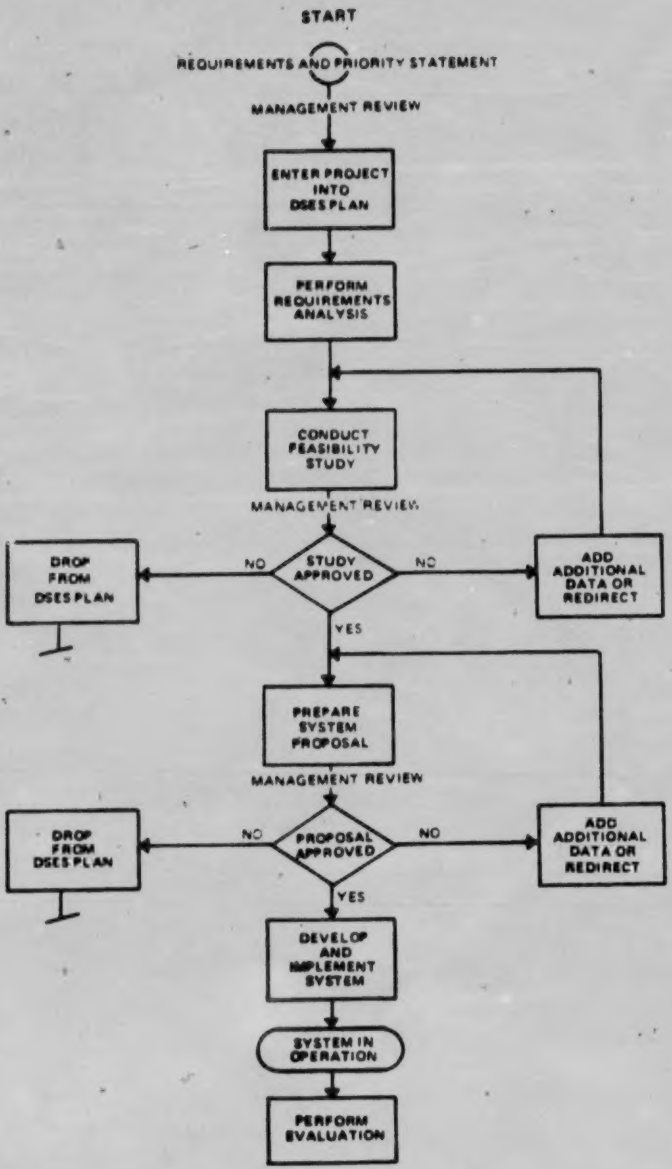

START
REQUIREMENTS AND PRIORITY STATEMENT
MANAGEMENT REVIEW
ENTER PROJECT INTO DSES PLAN
PERFORM REQUIREMENTS ANALYSIS
CONDUCT FEASIBILITY STUDY
MANAGEMENT REVIEW
DROP FROM DSES PLAN
NO
STUDY APPROVED
NO
ADD ADDITIONAL DATA OR REDIRECT
YES
PREPARE SYSTEM PROPOSAL
MANAGEMENT REVIEW
DROP FROM DSES PLAN
NO
PROPOSAL APPROVED
NO
ADD ADDITIONAL DATA OR REDIRECT
YES
DEVELOP AND IMPLEMENT SYSTEM
SYSTEM IN OPERATION
PERFORM EVALUATION

Figure 2 - **COMPUTER BASED INSTRUCT**

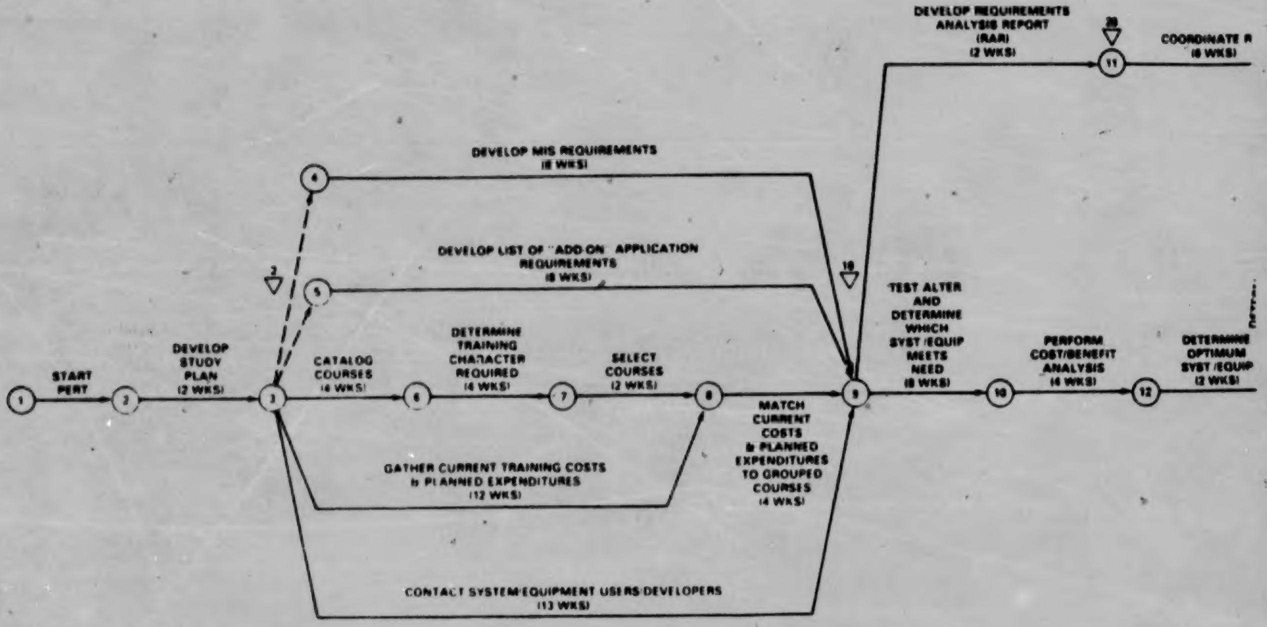
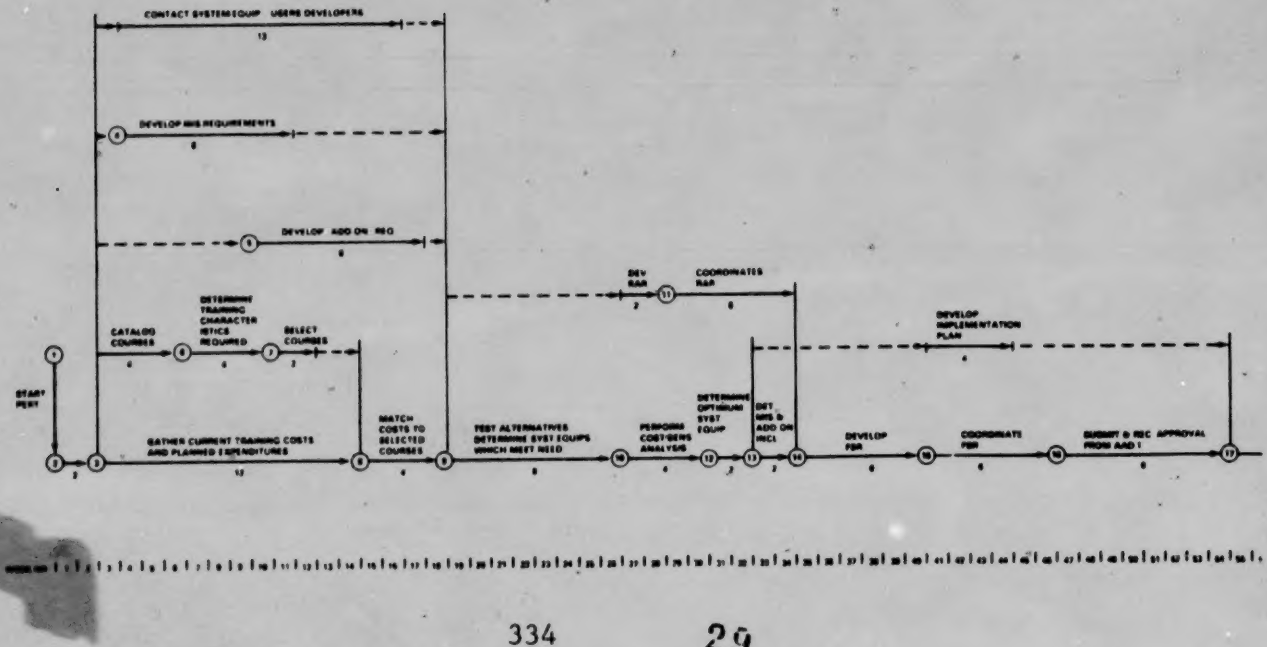
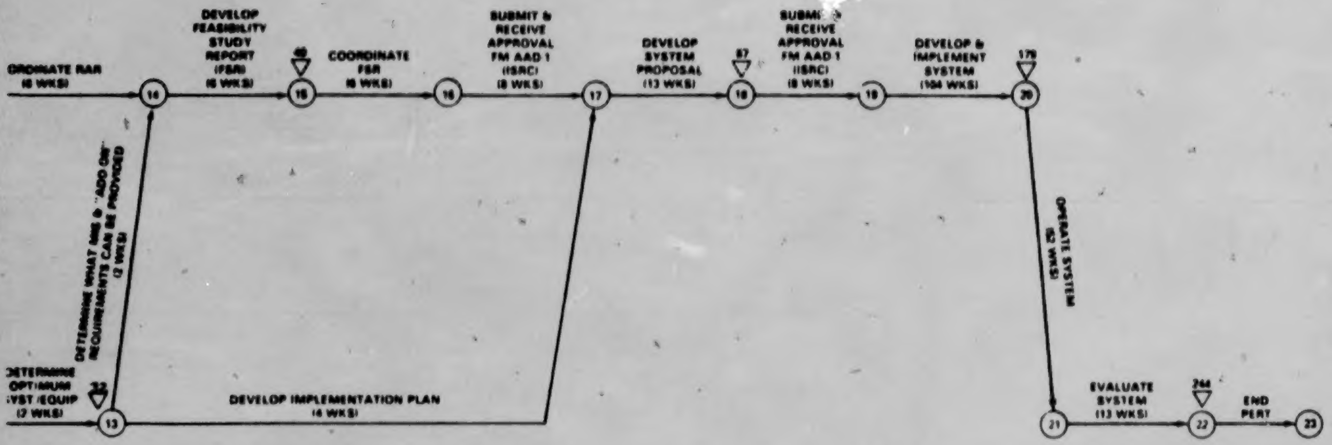

START PERT
DEVELOP STUDY PLAN (2 WKS)
CATALOG COURSES (4 WKS)
DETERMINE TRAINING CHARACTER REQUIRED (4 WKS)
SELECT COURSES (2 WKS)
MATCH CURRENT COSTS & PLANNED EXPENDITURES TO GROUPED COURSES (4 WKS)
GATHER CURRENT TRAINING COSTS & PLANNED EXPENDITURES (12 WKS)
CONTACT SYSTEM/EQUIPMENT USERS/DEVELOPERS (13 WKS)
DEVELOP MIS REQUIREMENTS (8 WKS)
DEVELOP LIST OF "ADD ON" APPLICATION REQUIREMENTS (8 WKS)
TEST ALTER AND DETERMINE WHICH SYST/EQUIP MEETS NEED (8 WKS)
PERFORM COST/BENEFIT ANALYSIS (4 WKS)
DETERMINE OPTIMUM SYST/EQUIP (2 WKS)
DEVELOP REQUIREMENTS ANALYSIS REPORT (RAR) (2 WKS)
COORDINATE R (8 WKS)
2
18
20
1
2
3
4
5
6
7
8
9
10
11
12

Figure 3 - **COMPUTER BASED INSTRUCT**

TIME ORIENTED PERT C

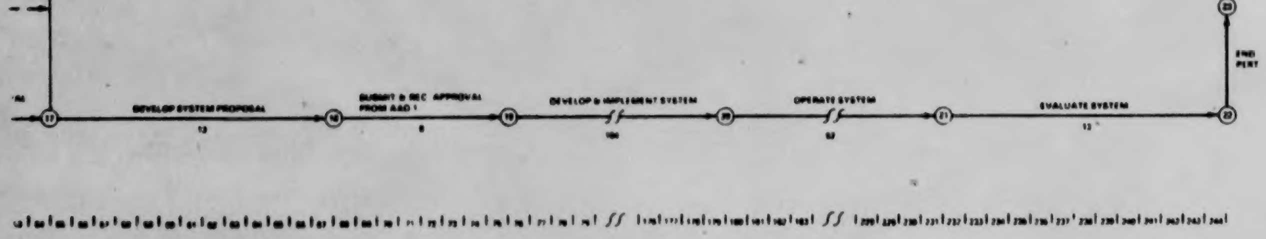

CONTACT SYSTEM/EQUIP USERS DEVELOPERS
13
DEVELOP MIS REQUIREMENTS
8
DEVELOP ADD ON REQ
8
CATALOG COURSES
DETERMINE TRAINING CHARACTERISTICS REQUIRED
SELECT COURSES
START PERT
GATHER CURRENT TRAINING COSTS AND PLANNED EXPENDITURES
12
MATCH COSTS TO SELECTED COURSES
4
TEST ALTERNATIVES DETERMINE SYST EQUIPS WHICH MEET NEED
8
DEV RAR
2
COORDINATES RAR
8
PERFORM COST/BENS ANALYSIS
4
DETERMINE OPTIMUM SYST EQUIP
2
DET MIS & ADD ON INCL
2
DEVELOP IMPLEMENTATION PLAN
4
DEVELOP FDR
8
COORDINATE FDR
8
SUBMIT & REC APPROVAL FROM AAD I
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

IUCTION SYSTEM – STUDY PLAN


ORDINATE RAR
(6 WKS)
DEVELOP
FEASIBILITY
STUDY
REPORT
(FSR)
(6 WKS)
40
COORDINATE
FSR
(6 WKS)
SUBMIT &
RECEIVE
APPROVAL
FM AAD 1
(ISRC)
(8 WKS)
DEVELOP
SYSTEM
PROPOSAL
(13 WKS)
87
SUBMIT &
RECEIVE
APPROVAL
FM AAD 1
(ISRC)
(8 WKS)
DEVELOP &
IMPLEMENT
SYSTEM
(104 WKS)
179
14
15
16
17
18
19
20
DETERMINE WHAT MIS & "ADD ON"
REQUIREMENTS CAN BE PROVIDED
(2 WKS)
OPERATE SYSTEM
(52 WKS)
DETERMINE
OPTIMUM
SYST/EQUIP
(2 WKS)
32
13
DEVELOP IMPLEMENTATION PLAN
(4 WKS)
EVALUATE
SYSTEM
(13 WKS)
264
END
PERT
21
22
23

IUCTION SYSTEM–STUDY PLAN

'ERT CHART


17
DEVELOP SYSTEM PROPOSAL
13
18
SUBMIT & REC APPROVAL
FROM AAD 1
8
19
DEVELOP & IMPLEMENT SYSTEM
104
20
OPERATE SYSTEM
52
21
EVALUATE SYSTEM
13
22
END
PERT
23

REQUIREMENTS ANALYSIS

The basic approach to the Requirements Analysis was developed in a working conference between education specialists, management analysts and subject-matter specialists. Ordinarily in an ADP requirements analysis a requirement is a discrete piece of data (e.g., an employee's payroll number) which needs to be processed or manipulated for a given purpose. The set of all such requirements would be the total requirement.

This traditional ADP approach obviously had to be modified for the CBI study since there are an endless number of steps and pieces of information which must be processed in a teaching situation. It was decided that the delivery of a single FAA course would be used as the basic data "element."

Since there are more than 1000 internal FAA courses, some further means of simplification seemed necessary. After considerable discussion, a proposed plan to identify a representative sample of courses for further analysis was rejected. Instead, it was decided that the study should concentrate on "high potential benefit" courses. A high potential benefit course was one judged by a subject-matter expert to be:

1. Costly due to:
    - A. High student volume, or
    - B. High student grade level, or
    - C. High training equipment cost;
2. Stable by virtue of:
    - A. Regular scheduling, and
    - B. Established subject-matter; and
3. Suitable for improvement because of:
    - A. The nature of the current learning activities, and
    - B. A supportive administrative environment

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Thus, the overall requirement is to teach the high potential benefit courses with less overall expense, in less time, at the current level of quality or better, and within certain methodological procedures and policies. Approximately 25 courses were identified as high potential benefit courses. Any alternative considered in the feasibility study will have to show a favorable cost/benefit ratio on the basis of only these courses. Any new system would presumably be extended to other FAA courses, but this possibility will not be considered in the quantitative portion of the feasibility analysis.

The most time-consuming part of writing the Requirements Analysis report turned out to be the description of the FAA learning environment management process and its associated policies. This explanation included discussion of the job-centered training concept (i.e., the instructional systems approach), instructional strategies and recognized methods of presentation requirements of student management and current automated recordkeeping, a description of the FAA's physical training facilities, and a discussion of the instructor workforce. It is planned to consider all of these training system elements in the feasibility study. At the time this paper is being written, coordination of the Requirements Analysis report is nearly complete.

FEASIBILITY STUDY

The feasibility study involves a comprehensive and objective analysis of all feasible manual and ADP solutions which fulfill the requirements identified above.

The feasibility portion of the study also includes full development of costs and benefits for each method of solving the requirements. Concurrent preliminary work on the Feasibility study began after completion of the first draft of the Requirements Analysis.

The first step was to develop several alternative solutions for accomplishment of the FAA training requirements. The alternatives are being examined considering the optimum training methodology for each "high potential benefit" course, using variations of equipment and systems which will accomplish the training. Finally, the cost of each approach, effectiveness, and time required to accomplish training will be analyzed.

After analysis a recommendation will be made regarding the optimum solution for accomplishment of FAA's training which will be used in the development of the system proposal phase of the study.

TEST PROJECTS

After the success of the initial CAI project at the FAA Academy, two test projects were initiated to assess the feasibility of remoted CBI and CMI.

In the first project, a course which had been taught in-residence at the FAA Academy in Oklahoma City, is being taught on-site in the agency's seven Flight Inspection Field Offices using PLATO terminals. A combination of CMI and certain CAI lessons, workbooks, video tapes, and slide cassettes, is being used. An instructor is available on-call at the FAA Academy.

In the second project, the BAL and JOVIAL programming languages are being taught in a purely CMI mode using only reference manuals and workbooks as learning resources. These 120 hour courses had been taught in a lecture mode and were converted to CMI in a few weeks with minimum staffing resources.

Although these projects have not yet been completed and final reports have not yet been written, these efforts appear to have been successful. A number of questions have already been answered by these projects, and it is hoped that further FAA experience will answer other areas of potential uncertainty.

COMPUTER-BASED GRAPHICS AND INSTRUCTIONS FOR MAP READING TRAINING

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Behavioral and Social Sciences
Alexandria, Virginia[1]

Research is being conducted at the Army Research Institute on applying the use of computer-based graphics and instruction to map reading and land navigation training. The impetus for this research is derived from several sources: research in computer graphics, the need for improved map reading training techniques, and the development of computer-based courseware for map reading.

RESEARCH IN COMPUTER GRAPHICS - Several computer-based education (CBE) systems have the capability to generate and display sophisticated graphics. Because the costs for supporting hardware for computer graphics are rapidly decreasing, it is likely that future generation CBE systems will have graphics capabilities. Costs associated with software development for computer graphics will remain however; people must still design and code graphics displays and decide when and where to use them in their lessons. Although educators often assume that the use of graphics enhances instructional effectiveness, there is little systematic evidence to support this belief. Two recent studies which looked at the use of graphics in computer-assisted instruction (CAI) found no evidence that adding graphics to a textual presentation (King, 1976), or increasing the complexity of the graphics used (Moore, Nawrocki, and Simutis, in press) increased either instructional effectiveness or student motivation. In a review of the literature of graphics in non-CAI education and training (Moore & Nawrocki, in press) the same result holds true; simply adding graphics or increasing the reality of the instructional graphics does not guarantee a corresponding increase in instructional value.

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[1] The opinions expressed in this paper are those of the author and do not necessarily reflect those of the Department of the Army.

The use of graphics and visuals in instruction has much face validity, however. Clearly there are many tasks in which graphics of some sort are helpful, if not required, for successful learning and performance. The question is not, are graphics required for instruction, but rather what are the underlying variables which make some uses of graphics more effective than other uses. A determination of the effects of these variables will allow the design of principles from which CAI developers can deside when and where to apply cost effective graphics in their courseware development.

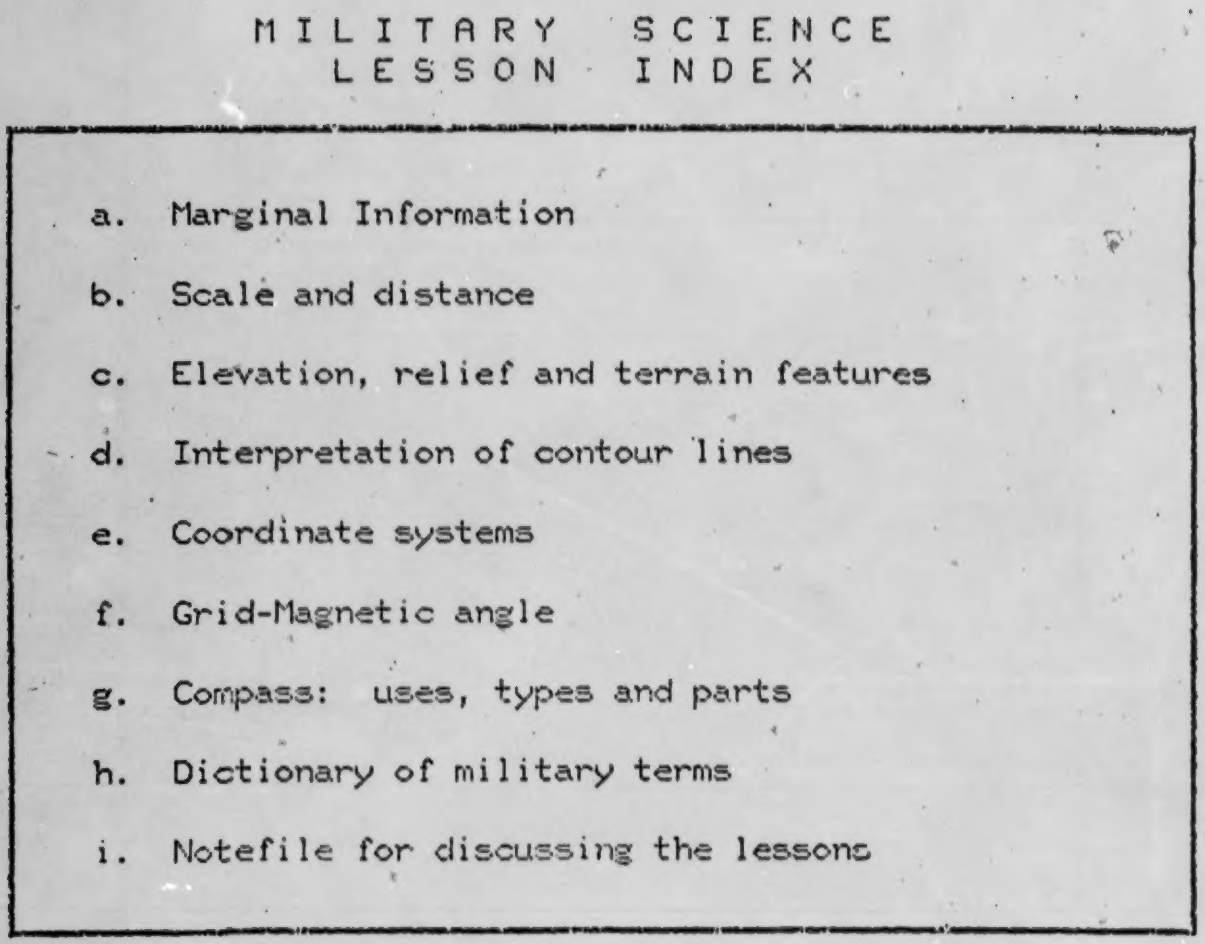
One probable class of tasks where the use of graphics may enhance learning are tasks which require interactions with the visual world. Map reading is one such task with military significance: in addition to being able to read map symbols, a good map reader must be able to visualize three dimensional space from a two dimensional map. Thus map reading training may provide a useful paradigm in which to explore variables which influence the effective use of graphics.

NEED FOR IMPROVED MAP READING TRAINING TECHNIQUES - The ability to read a military map is a necessary skill for many soldiers, yet it requires complex cognitive skills which are difficult to train. In addition to being able to understand map symbols and terminology and to perform the mathematical operations required to judge locations and distances, a good map reader must be able to visualize three dimensional terrain from its two dimensional map representation. Military maps use contour lines to show elevations at various points within the map, with contour lines connecting points at equal elevations. The patterns formed by contour lines represent different terrains and land formations.

By far, the most difficult map reading skill to train is terrain visualization from contour lines. Trainers generally agree that there are large individual differences in this ability and that the best map readers are those with the most experience. Currently the primary training for terrain visualization consists of field experience usually with the trainer walking alongside students and indicating land formations and their associated contour line patterns on a map. This training is limited in time and does not provide experience with a large variety of terrains. The bulk of the formal training time is spent in the classroom learning the mathematical techniques and symbology required for map reading.

Many of the problems of map reading training are likely due to the limited number of classroom and field hours which can be devoted to the topic. For this reason alone the use of CAI to replace or augment traditional instruction has high potential for improving current map reading training methods. In addition, computer-based graphics technology has been developed which might afford students added experience with terrain visualization.

COURSEWARE DEVELOPED - The University of Illinois Army ROTC Unit developed a series of computer-based lessons for training ROTC students in map reading. These lessons were developed on the University of Illinois PLATO System and provide instruction in the topics shown in Figure 1. Two undergraduate students, David Lesney and Gary Turner, initially under the guidance of CPT John Organek, designed and coded the courseware. In addition to providing training in standard map reading topics, an innovative method for generating terrain displays from a contour map is used to provide practice with terrain visualization. In the lesson called "Interpretation of Contour Lines" a simplified contour map is displayed in the upper half of the screen, as in the upper part of Figure 2. The student is allowed to move a


MILITARY SCIENCE
LESSON INDEX

a. Marginal Information
b. Scale and distance
c. Elevation, relief and terrain features
d. Interpretation of contour lines
e. Coordinate systems
f. Grid-Magnetic angle
g. Compass: uses, types and parts
h. Dictionary of military terms
i. Notefile for discussing the lessons

Figure 1. Lesson index for map reading lessons developed by David Lesney and Gary Turner at the University of Illinois

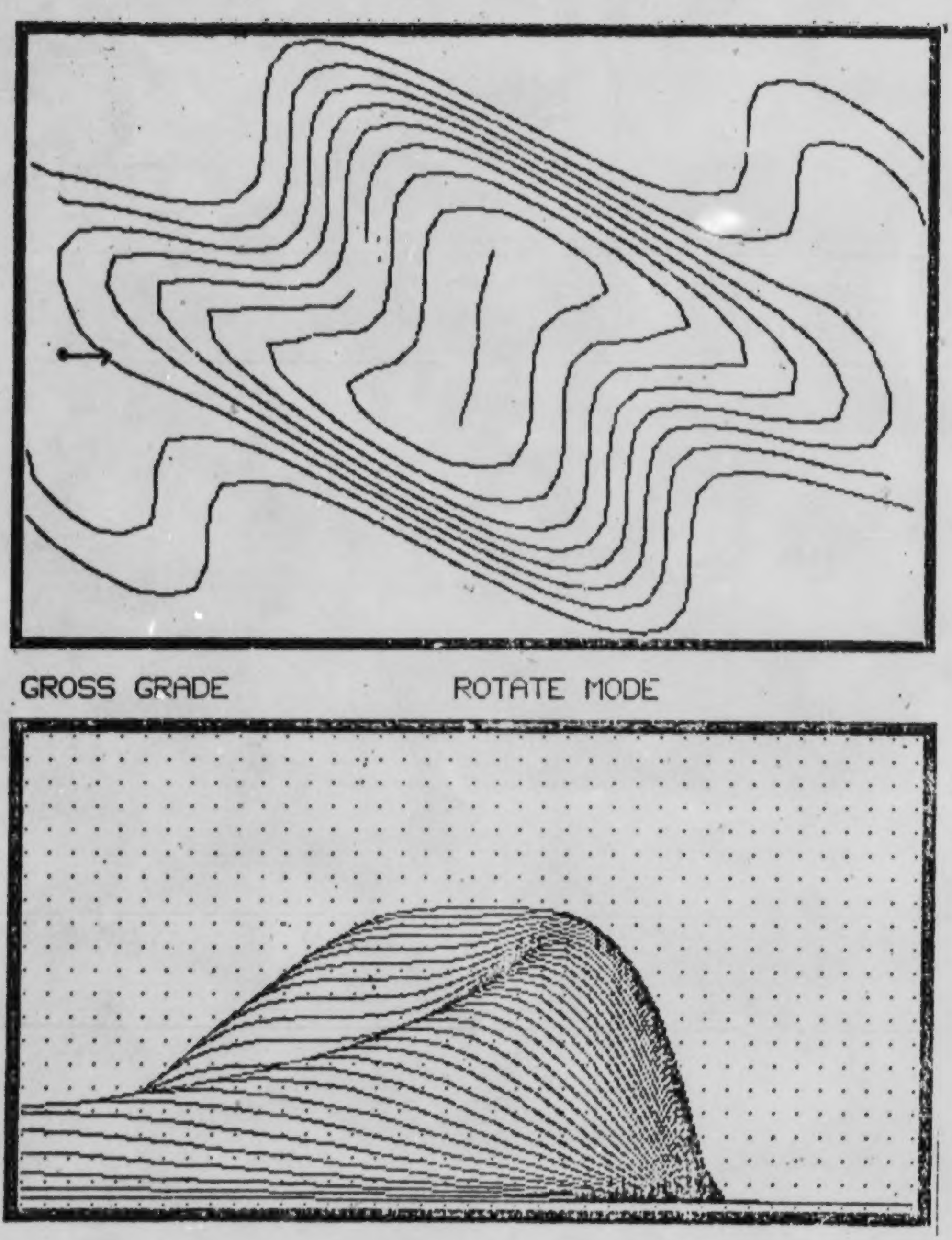

GROSS GRADE
ROTATE MODE

Figure 2. Example of contour map and terrain visualization from the indicated point and direction on the contour map

cursor anywhere on the map and to point the cursor's arrow in any direction. Once location and direction are indicated the student can request a display of the terrain that would be seen if the student were actually standing in that position and looking in that direction. The lower portion of Figure 2 shows the terrain visualization for the location and direction indicated in the contour map. (Those readers unfamiliar with reading patterns of contour lines should readily see in Figure 2 why terrain visualization is a difficult process). Five different maps and an option to view ground profiles are available. Ground profiles are drawn by moving the cursor from one point to any adjacent point on the map. As the cursor is moved the lower portion of the screen plots the relative elevations at each point. Thus students can also practice with contour interval-slope relationships, for example.

Two techniques are available for computer-based terrain visualization - digitized terrain techniques where terrain is drawn from stored data points or parameterized techniques where displays are generated using bivariate normal probability density functions. A modification of this latter approach is used in this lesson; it requires less storage and is more flexible for generating a variety of visualizations.

CURRENT RESEARCH ACTIVITIES. An experiment using the techniques developed at the University of Illinois by David Lesney for terrain visualization is in progress. The purpose of the experiment is to investigate two variables which are thought to influence map reading (and the effectiveness of graphics) - individual differences in spatial abilities (high vs low) and form of experience with the computer graphics (active vs passive).

After a general introduction to contour lines (a revised version of the lesson "Evaluation, Relief, and Terrain Features") soldiers see one of two versions of the lesson "Interpretation of Contour Lines." In the active version, students are allowed to freely explore each of the five contour maps, making decisions about which terrain visualizations and ground profiles they see. In the other version, the points and directions for terrain visualization and ground profiles on the contour map are randomly determined and the student acts as a passive observer. Half the subjects using each version have low spatial aptitude. The other half have high spatial aptitude. Ability to interpret contour lines, determine slopes, and identify land formations are tested using a paper and pencil test after the training session.

Results will have several implications. The applicability and effectiveness of the computer-generated graphics for map reading training will be assessed. Passive observation of contour line-terrain visualization relationships require considerably less computer storage and visualizations can be generated more quickly. In fact, passive observation does not require computer-based techniques; a simple slide show could easily replace the computer. Thus, the added benefits of active student participation using the more costly graphics capabilities uniquely suited to the computer can be assessed. In addition, the interaction effect of spatial aptitude and student activity will be considered, thus the results will also have implications for media selection.

A research and evaluation plan also has been developed to apply computer-based graphics and instruction to map reading training in the Army. Included were recommendations for lesson revisions and suggestions for additional lessons. The basic research effort described above provides the initial assessment of the feasibility of introducing computer-based graphic techniques for improved terrain visualization training.

REFERENCES

KING, W. A. A comparison of three combinations of text and graphics for concept learning. NPRDC Technical Report 76-16, 1975.

MOORE, M. V., and Nawrocki, L. H. The educational effectiveness of graphics displays for computer-assisted instruction: Where are we, where do we go? ARI Technical Paper (in press).

MOORE, M. V., Nawrocki, L. H., and Simutis, Z. M. The instructional effectiveness of three levels of graphics displays for computer-assisted instruction, ARI Technical Paper (in press).

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NAVAL TACTICAL ACTIONS WAR GAME (NAVTAG)

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Annapolis, Maryland

ABSTRACT:

The Naval Tactical Actions simulation is not in the true sense of the word, a simulation; but rather an interactive, multi-terminal program. It is utilized as a teaching and testing device for material presented in tactical warfare courses at the Naval Academy. Participants compete in simulated battles with one another rather than with a computer. Each team is assigned two terminals. One terminal is dedicated to communication with the program; the other furnishes graphic displays of battle events.

The battle scenarios of the game are composed of aircraft, surface, and sub-surface platforms. There are various types of vehicles within each category of platform. Vehicle movements are graphically displayed at scale speeds and are limited to the characteristic speed maximum for that vehicle type. The number of different scenarios that can be constructed using combinations of vehicle types is almost limitless.

Each vehicle may have several different types of weapons. The weapon systems available for use at any one time are only those characteristic of a given platform. Weapon types include: rapid fire small caliber guns, large guns, missile systems, torpedoes, glide bombs, standard bombs, and anti-submarine rockets. Weapons are limited to inventories, range maximums, specific uses, and other special conditions that might affect the performance of a weapon.

The main program and its associated subroutines initiate necessary maneuvers and actions upon receiving various types of commands from the players. The commands allow the players to control course and speed for each vehicle and to activate the weapon systems. In addition, these commands control the state of combat readiness for each side in the battle. Combat readiness is exercised by the general quarters, sonar, chaff, and jamming commands. The status of

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combat readiness tends to improve or degrade the ability of detection and the results of offensive and defensive actions.

The program also maintains a record of damage information. A current damage report is furnished to each player, or team, following a battle exchange, and a consolidated report is displayed on command. Accumulated damage affects vehicle performance in respect to vehicle speed and weapon effectiveness. Sufficient damage results in total "disablement" or "destruction" of a platform.

The use of the model under classroom conditions proves that successful players are those who are most familiar with platform and weapon characteristics and are able to put their acquired knowledge to good use. Thus, the NAVTAG simulation is an effective teaching tool for three reasons. First, students must acquire knowledge of course material beforehand for effective participation in the game. Secondly, the instructor can measure the students depth of knowledge of tactical warfare and their ability to apply such knowledge through their degree of success or failure in the game. Finally, since participation in the game is an enjoyable experience, students learn easily and "painlessly."

INTRODUCTION

GENERAL

The emergence of the Soviet Navy as a major global force has been one of the most significant developments of recent history. The naval supremacy held by the United States following the Second World War was unquestioned until perhaps ten years ago. The role of naval developments in international relations cannot be disregarded, and the interplay between Soviet and American forces will have considerable impact in the decades to come.

In this context, the training of Naval officers in modern tactics has become imperative. An advanced technological world has spun a complex web of electronic sensors and supersonic weaponry. Gone are the days of wooden sailing ships and crossing the "T". If one incorrect decision is made in the first minute of a battle, there may be no second chance. It is essential, then, to evaluate the probable outcomes of many hypothetical situations and actions, which hopefully will never occur.

One of the primary tools used in tactical training is the war game. A war game can be a manual table top game or a highly sophisticated computerized model. Games such as chess or checkers can be rightfully regarded as war games inasmuchas one player attempts to "capture" or "destroy" the playing pieces of his opponent. The player benefits by learning different strategies for attack and defense. The mark of consistently victorious players is the tactical proficiency they have attained in order to gain an advantage over their opponents. War games, then, provide a bloodless, economical method for sharpening the skills of tacticians.

Some efforts have been made at the Naval Academy to incorporate rudimentary tactical training into the traditional academic curriculum. The Naval Tactical Actions Game (NAVTAG), a table top game developed by LT Neil Byrne, USN, was introduced in a senior level tactical warfare course. The course featured lectures by technical experts in various fields of weaponry and warfare, and was supplemented by the use of the game. NAVTAG provided a means of putting the knowledge gained from the lectures to a meaningful test. The game itself consisted of scale ship models, probability tables, and dice.

DISADVANTAGES

Table Game

Even though the manual NAVTAG board game performed a valuable service in the Naval Academy curriculum, some features of the game fall short of the expectations of the course instructors.

1. Movement of the platform models was accomplished manually, and distance was measured with a ruler. Line maneuvering practice was minimal.

2. Constant throwing of dice for hit, detection, and damage decisions was tedious, time consuming, and not always accurate.

3. Consistent application of probability checking and damage assessments by the referee were also tedious and time consuming tasks.

4. The lack of some form of battle firing dramatization made the action sequence very bland and sometimes disappointing.

5. In more complicated scenarios, damage accountability became a problem. Lists of disabled weapons systems, inventory totals, and loss of vehicle capabilities had to be hand tabulated.

6. Several complex scenarios were difficult to complete within the fifty minute class period. Premature termination of a scenario contributed little knowledge to the participants and often resulted in frustration.

DEVELOPMENT OF THE COMPUTER GAME

The computerization of the NAVTAG board game eliminated the inadequacies of the original manual game and offered opportunities for new ideas, improvements, and methodology. The computerized version* replaced the table top and platform models with a graphic display screen.

In the game, ships move at scale speeds and players are required to specify course and speed, thereby practicing line maneuvering. Verbal orders, commands, and plans are input through a terminal keyboard using a concise, meaningful code. The confidentiality of maneuvers and battle plans is maintained. The referee/instructor has been relieved of tedious "bookkeeping" and is the monitor and advisor. The computer program receives commands, checks limitations and specifications, moves vehicles, maintains inventories, assesses damages, and furnishes reports. The increased speed of computation and the elimination of manual tasks make possible the completion of the most complex scenarios within the allotted class time.

CONFIGURATION OF THE GAME

The NAVTAG computer game utilizes four computer terminals; two for each team, Red vs. Blue. The terminals for opposing teams are generally placed at different locations, to elicit a feeling of separation. For each team, one terminal is used exclusively for graphics display. The second terminal is used for all input and all printed output. The separation of text and graphic functions allows players to have a constantly updated battle display while inputting commands and receiving information. The players for each side make decisions based on both the graphically displayed picture and the printed messages. Tektronix storage tube terminals are used for graphic displays. The program is used on the Dartmouth Time-Sharing System (DTSS) in conjunction with a Honeywell 6060 computer and utilizes a DTSS system module to handle the multiple terminal interaction.

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* We would like to acknowledge the contributions of LT R. S. Herbert for promoting the computerization of the manual game and for lending his expertise in weapons systems and tactical warfare in supporting the development of this program.

Internally, the model is of a degree of complexity sufficient to produce fairly realistic outcome. The design of the NAVTAG computer game was based on its function as a teaching, rather than analytical, tool. The simplicity of the model is considered a positive point in this respect.

VEHICLE MOVEMENT

GENERAL

In scenarios involving only surface and subsurface platforms, players may selectively maneuver their units at the beginning of each move. The players may specify a new course, speed, and depth (submarine only) for any vehicle they choose. The requirement for maneuvering by the players gives them valuable experience in line maneuvering. Proper location and positioning of platforms are important in tactical warfare.

In air scenarios, only the attacking air units are manueverable, and then only by altering their altitudes. Courses of aircraft flight groups are fixed.

Vehicles start the game on the course indicated by their graphical representations. Depending on the type of vehicle, players are requested to input maneuvering changes by specifying course, speed, and, when applicable, depth and altitude.

If the player indicates no maneuvering changes, the program maintains all vehicles for that team at their current course and speed.

If there is more than one unit in the force, the player must furnish the unit name of the platform he wishes to maneuver. Vehicle name input can be abbreviated and all or part of a ship name known internally to the program will be accepted. If the program is able to identify the ship from the letters submitted, the input is accepted. The truncated names used on the displays are normally safe to use.

If the platform specified is a submarine, the current depth is printed and a new depth requested. The player may type "0" (periscope depth), 250, 500, 750, or 900 for the submarine depth. A submarine may ascend or descend only in increments of 250 feet for each move.

If any platform other than air units is specified, the current course is printed and a new course requested. The player may input any whole number of degrees from 0 to 359 to change the ship heading.

The current speed (for non-air units) is furnished to the player prior to the request for a new speed input. Any speed (designated in knots) from zero to maximum of the given vehicle can be used. If a speed greater than the maximum permitted for the ship is submitted, the maximum speed possible is executed.

For air units, the current altitude of the plane (or group of planes) is given, and a new altitude requested. The player may input 50, 500, 1000, 5000, or 10000 for the new altitude of the plane(s).

ADDITIONAL NOTES

1. Top speed of surface vehicles is reduced with the accumulation of damage.

2. No provision has been made for collisions between vehicles or for running aground.

3. Altering the course of a surface vehicle by more than 90 degrees reduces the distance traveled by one half for that move.

4. Each individual plane and ship is allowed one altitude change, one depth change, or one heading/speed change per move.

5. Input of a negative heading for a new course results in an error message and the vehicle proceeds on a random course.

6. Input of a negative speed for a vehicle results in a speed of zero.

7. Air scenario - (See Fig. 1)

a. The heading of the surface vessel is altered by 30 degrees in each move and remains graphically stationary to maintain its position in the center of the display.

b. The aircraft may ascend or descend any number of altitude levels in one move.

c. Altitude changes are recorded and stored for testing the required conditions while firing shrike missiles.

d. When all A7 flights are "dead" or "empty", the EA6B's will turn on a course of 300 degrees and leave the scene.

e. When all the aircraft in a given flight have expended their weapons, they will change course to 300 degrees and leave the scene.

ACTION COMMANDS

Generally, events of the simulation are dictated by movement of the platforms by players and the use of action commands. Action commands are specified in a keyword list. Platform status and weapon commitments are controlled by user input of the keywords. The keywords are as follows:

KEYWORDS

GQ . . . General Quarters
CHAFF. . Chaff
JAM. . . Electronic Jamming
SNR. . . Sonars
GUN. . . Gun Firing
TOR. . . Torpedo Firing
MIS. . . Missile Firing
BOM. . . Release of Bombs
SCA. . . Rescale Graphic Picture
DAM. . . Furnish Damage Report
CON. . . Continue (no further keyword input)

GRAPHIC DISPLAY AIR VS SURFACE

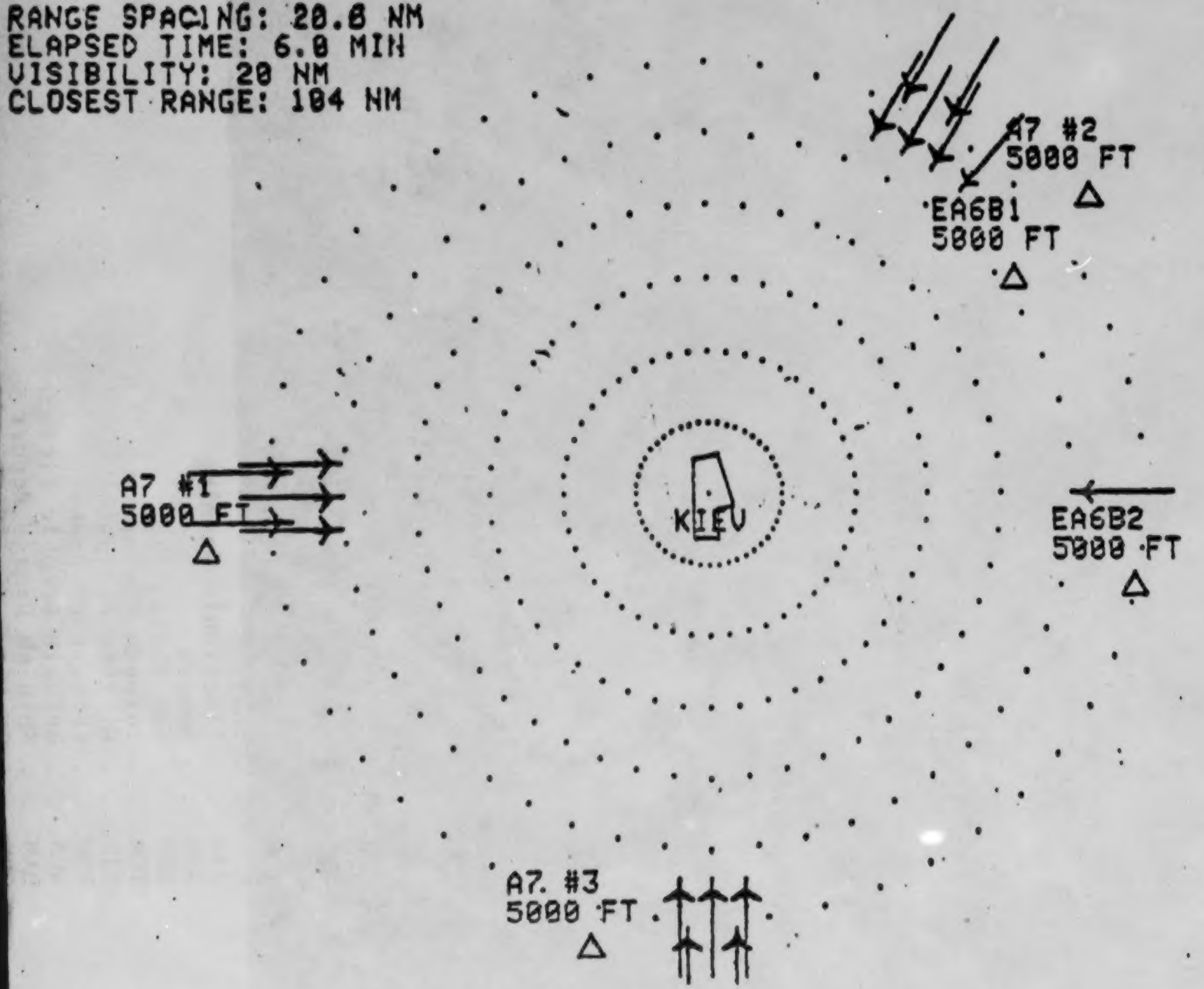

RANGE SPACING: 20.0 NM
ELAPSED TIME: 6.0 MIN
VISIBILITY: 20 NM
CLOSEST RANGE: 104 NM
A7 #2
5000 FT
EA6B1
5000 FT
A7 #1
5000 FT
KIEV
EA6B2
5000 FT
A7 #3
5000 FT

FIG. 1

KEYWORD DESCRIPTIONS

1. GQ . . . initiates general quarters status for all platforms on a player's force. Each side must call general quarters separately. Failure to do so prior to offensive/defensive actions reduces platform strike capability by 50% for offense and increases the probability of being hit for defense. General quarters command activates platform sonars (if applicable) to the passive mode and turns on search radar systems.

2. CHAFF. . causes chaff to be fired or released from platforms and thereafter affects missile hits and defense.

3. JAM. . . activates electronic jamming on applicable vehicles. Air scenarios graphically display jamming from the aircraft.

4. SNR. . . turns sonars to passive, active, or off for applicable vehicles.

5. GUN. . . allows players to fire guns at surface or air targets. Each separate gun record on the platform requires a separate commitment input. For airborne targets (missiles, planes, and walleye bombs), gun records that represent two gunmounts have both committed to the same target.

6. TOR. . . allows the player to launch or fire one or more torpedoes against an enemy target. The number of questions that follow this command vary according to the type of target (surface or subsurface) and the type of the attacker (surface or sub-surface). Input requirements are: target/attacker names, Asroc or tube launch, target bearing at time of impact, range at time of impact and initial search depth.

Determining Torpedo Probability of Hit

(1) The key factor in determining the probability of hit for all tube-launched torpedoes is the distance traveled from the point of launch to the approximate point of interception.

(2) The type and depth of a submarine target affects the probability of hit for both Asroc and tube-launched torpedoes. A conventionally propelled submarine has a greater chance of being hit than a nuclear type. A submarine at periscope depth has a greater chance of being hit than one at 900 feet. The depth setting of the torpedo must match the submarine depth for any chance of hit.

(3) If the launch sequence requires input of a projected bearing and range to the target, values must be within 15 degrees and 1000 yards respectively for any chance of hit.

(4) If the target is a submarine, probability of hit is decreased by 1/2 if the attack is "urgent", rather than "deliberate." In order to launch a "deliberate" attack on a submarine, a surface ship must either have three consecutive sonar contacts, a radar contact, or a detection of active submarine sonar.

(5) Probabilities of hit for submarine-launched torpedoes are cut by 1/2 if the submarine does not make a periscope sighting prior to the time of launch.

Angle Restrictions

The placement of the launchers or tubes must be considered in relation to the ship heading and target bearing for torpedo launches. A brief summary of the restrictions imposed by various locations and weapon types follows:

For a PT boat attacking a surface ship, the heading of the attacking unit must be within 15 degrees of the target bearing for the highest probability of hit. The torpedo follows the attacking unit's heading with less chance of hit if the target is outside the 15 degree range. If the player shoots at a target behind the attacking PT boat, he is penalized by losing these shots, which trail off the screen and "explode."

For a Red surface ship attacking a Blue surface ship, Red torpedoes fired from port or starboard tubes may be launched within 120 degree sectors off the port or starboard beams. Tubes mounted amidships can launch within the same sectors on either side.

For a submarine attacking a Blue surface ship, Red torpedoes launched from the forward tubes may be aimed at targets within 60 degrees of the heading.

Torpedoes launched from aft tubes can be aimed 60 degrees on either side dead astern.

For a Blue surface ship attacking a Red submarine, Blue torpedoes launched from tubes mounted port or starboard can be aimed at targets within 70 degrees of the heading. Both port and starboard tubes can be used against targets on either side of the ship's heading.

Asroc launchers mounted forward can be fired at targets within 90 degrees of the heading.

Asrocs mounted midships can be fired at targets within 120 degree sectors of the port and starboard beams.

Additional Notes

(1) Torpedo launches may be detected by enemy ships, provided they have called general quarters. Detection is indicated on the opposing force's terminal, along with the bearing from the target ship to the torpedoes.

(2) No more than one ASW torpedo can occupy the same location at the same time. Torpedoes within 500 yards of each other destroy one another.

(3) Asroc launches should not be targeted too close to the friendly ships. Any Asroc targeted within 500 yards of a friendly ship is given a 50% chance of hitting that ship.

(4) Each torpedo that hits a surface ship (other than a carrier) is also given a 20% chance of scoring a magazine hit. One torpedo hit sinks a submarine.

(5) Asroc-launched torpedoes that miss their intended target will remain at the same location for five moves for interference purposes. If another torpedo approaches within 500 yards, they detonate one another.

(6) Submarine torpedo tubes are not reloaded until six moves after all tubes at that physical location are emptied.

(7) The range estimation requirement for firing torpedoes is simplified by range rings on the display. The rings appear when the "TOR" command is used.

7. MIS ... allows players to fire missiles

The program requires certain information to initiate firing one or more missiles at surface or air targets. The information required depends upon which team is firing the missiles and the type of target. Players must input attacker and target name, name and number of missiles to fire, number of the director to use and the platform from which the target originated if that target is a missile.

Additional Notes

(1) General

(a) The number of commitments made by any one Blue ship is limited to the number of targets the directors on that ship can acquire.

(b) Any director is automatically linked to any launcher.

(c) A missile director can acquire targets regardless of its physical position on the platform or the bearing to the target.

(d) Launchers disabled due to damage reduce the rate of fire and missile inventory.

(e) The maximum number of directors on any ship is five.

(f) The rate of fire per move can be attained without utilization of all available directors.

(g) Firing at opposing missiles requires the identification of the opposing platform which is firing the missiles to be targeted.

(2) Blue Notes

(a) Fire control system directors can be used only for the type of weapon for which they are designated.

(b) Sea Sparrow commitments automatically commit two Sea Sparrow missiles. Only two missiles can be fired per move.

(3) Red Notes

(a) Red missile firings are done without need for specific director identification.

(b) The number of targets a ship can acquire is determined by the number of directors and the number of targets acquired by each director.

Shrike Missile Notes

Radar targets for shrike missiles must be designated at the beginning of the game. Choices are: "HEADLIGHTS", "POP-GROUP", "TOPSAIL", and "HEADNET". Failure to designate missiles for proper fire control radar systems causes missiles to be lost when launched. If properly designated, the target radar system must be "hot" (have illuminated a target) and remain "hot" throughout the flight of the missiles to the target. If the Red side fails to fire missiles for one move while shirke missiles are in flight, the fire control system is turned off and the shrike missiles are lost. Shrike missile hits inflict 5 points damage to the platform and destroy fire control systems. Aircraft altitude changes must be done in the move prior to planned shrike launching.

8. BOM ... allow players to drop or launch bombs from aircraft (for AAW only)

For dropping or launching bombs, the program requires attacker name, target name, bomb name, and number of bombs.

9. SCA ... allows either player to rescale the graphic display in the event that one or more vehicles move off the screen and out of sight. It may also be desirable to rescale should a scenario commence at a very small scale and vehicles closing at short range are out of the perspective of the scale.

10. DAM ... allows the players to obtain a damage status report concerning specific damage inflicted on a side's own platform. It is not possible for one side to obtain damage reports for the opposing force. Damage reports are automatically furnished to both

sides immediately following firing displays and at the termination of the game.

11. CON ... used by players to signify that there is no further need for keyword input and the game should continue. Use of the continue command by the Red side is followed by keyword input by the Blue side. Input of the continue keyword by Blueside is followed by "FIRE BUTTON" input and action displays (provided commitments have been made).

SEQUENCE OF EVENTS

The normal sequence of events for execution of the task force simulation is as follows:

SURFACE VS. SURFACE (SEE FIG. 2)

There are various surface/surface configurations. See the table on the next page.

STEP 1. Red may specify course and speed changes of any or all of its ships. The changes are registered by the program but not displayed.

STEP 2. Blue may make course/speed changes as above.

STEP 3. Both graphic screens are updated with new platform courses and positions.

STEP 4. Red may utilize keywords to call general quarters; fire chaff; initiate jamming; turn sonar on/off; and fire guns, torpedoes, or missiles. Illumination messages are given to the opposing side when weapons with fire control systems are committed to surface targets. "COMMIT" lines for each commitment of weapons appear on the red graphic terminal indicating the attacker and target.

STEP 5. Blue may utilize keywords for offensive and defensive actions. Information and rules given above in STEP 4 apply.

GRAPHIC DISPLAY SURFACE VS SURFACE

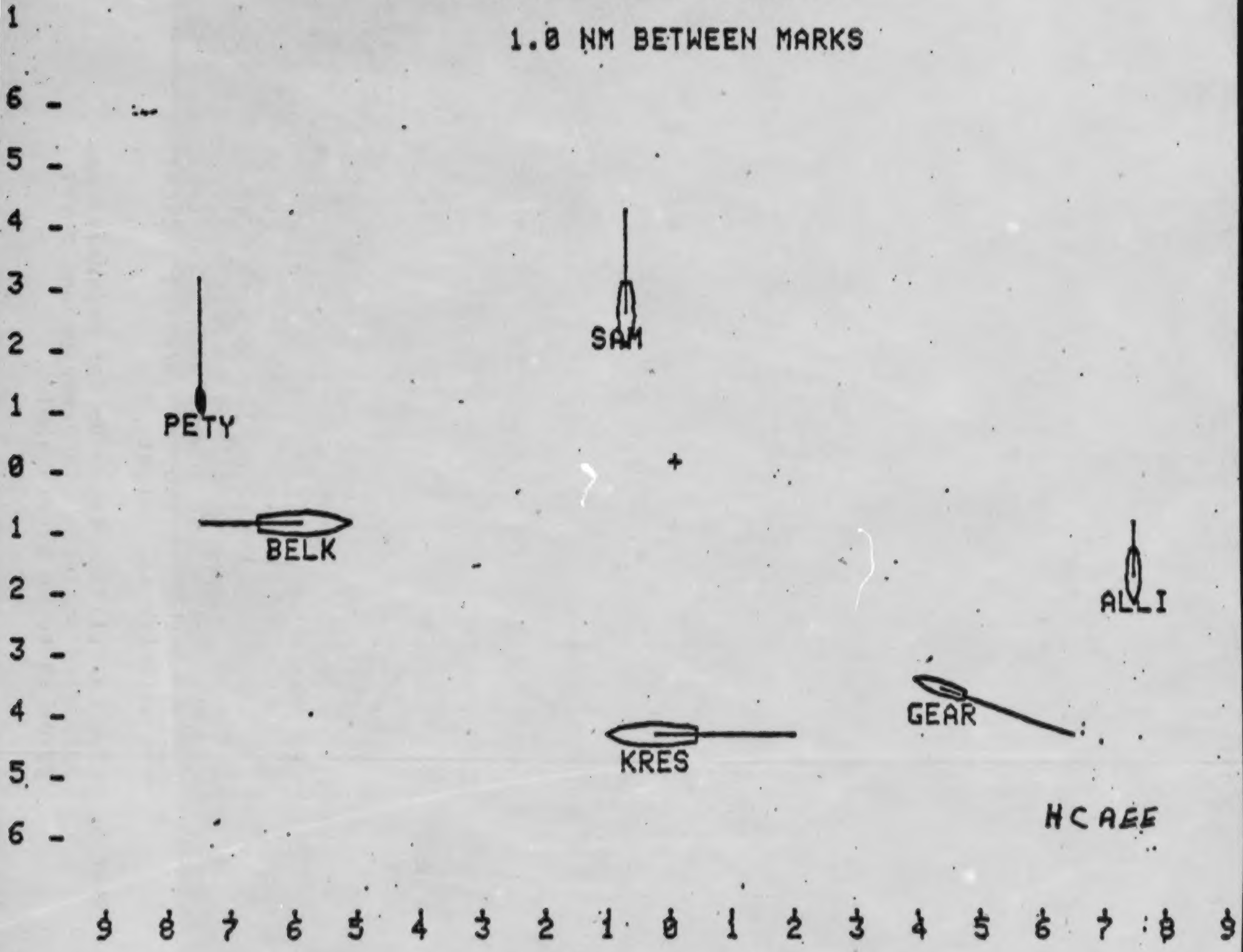

1.0 NM BETWEEN MARKS
1
6
5
4
3
2
1
0
1
2
3
4
5
6
SAM
PETY
BELK
ALLI
GEAR
KRES
HCAEE
9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9

FIG. 2

STEP 6. Following the completion of weapons commitments by Blue forces, each side receives a message "PRESS F KEY TO FIRE WEAPONS" (provided weapons commitments have been made). After the "FIRE" buttons are pressed by both sides, the exchange of missiles, guns, and torpedo shots is executed and displayed on the graphic screens.

The program assesses damages to the proper platforms when hits occur, and furnishes battle/damage information to each side via the input/output terminals. Following the exchange, Red forces may specify course/speed changes. (Return to STEP 1.)

AVAILABLE SURFACE VS SURFACE SCENARIOS

(Names indicate ship class)

SHERSHEN (6)	VS	SPRUANCE (1)
SHERSHEN (6)	VS	KNOX (1)
KYNDA (1)	VS	ADAMS (1)
SAM KOTLIN (1) PETYA II (1) ALLIGATOR (1) KRESTA II (1)	VS	BELKNAP (1) GEARING (1)
SAM KOTLIN (1) PETYA II (1) ALLIGATOR (1) KRESTA II (1)	VS	CALIFORNIA (1) GEARING (1)

AIR VS. SURFACE (SEE FIG. 1)

The air scenario is composed of two EA6B type aircraft and three flights of five A7 type aircraft (Blue side) versus a Kiev class carrier (Red side). Three different scenario configurations are possible which differ in weapon load and direction of attack for the aircraft. The surface ship is placed in the center of the display and its heading is altered by 30 degrees each move.

STEP 1. The Blue side is informed of aircraft types, quantities, and weapon loads. A graphic display informs the player of the relative positions of the single aircraft and flights in relation to the target. The player may, at any time, choose different initial range distances from the target for the different flights.

STEP 2. If Recon-ECM type aircraft are involved, the player must make a choice within each of the following categories:

1. Whether ECM aircraft should accompany flights or operate independently.
2. Whether ECM aircraft should orbit when reaching a target range of 24 miles or continue with the fighter flights.
3. Whether ECM aircraft are jamming or not.

STEP 3. If shrike missiles are available as weapons on air platforms, the player must choose which radars on the target platform are designated as targets.

STEP 4. The player with aircraft platforms makes altitude changes if he desires. All aircraft begin the mission at 5000 feet. The altitude choice made at this time remains without change until the closest range from nearest aircraft to the target is 40 miles.

STEP 5. Aircraft move toward the target from 152 to 40 mile range with pauses to renew graphic screens when new detections are made by the surface vessel. Upon reaching the 40 mile range, the Blue side again has the opportunity to alter aircraft altitudes.

STEP 6. Red side may input keywords for general quarters, jamming, chaffing, firing missiles or guns.

STEP 7. Blue side has opportunity to input keywords as did the Red side in Step 6.

STEP 8. Following the pressing of "FIRE" buttons by both sides, the program displays action graphics, assesses damages, and outputs damage reports to both sides. Blue side may alter aircraft altitudes and the procedure returns to Step 6. Steps 6-8 are repeated until the conclusion of the mission.

SUBMARINE VS. SURFACE (SEE FIG. 4A & 4B)

The ASW scenario is composed of a November class submarine for the Red side and a carrier accompanied by four screening ships for the Blue side. All Blue platform positions are on a course of 090 degrees and all speeds are preset at 10 knots.

The submarine is on a course of 270 degrees at a depth of 250 feet. The submarine is randomly positioned in front of the task force at a range of 5 miles and on a bearing ranging from approximately 070 degrees to approximately 110 degrees.

STEP 1. The Blue side (surface ships) is informed of the mission and is given an intelligence message concerning hostile submarines in the area.

The Red side (submarine) is informed of its mission and given information of a task force detection.

STEP 2. The Blue side has a choice of tactical actions by the screening ships and the carrier: patroling, proceeding on base course, or zig-zagging. Making the proper choices delays issuance of task force progress reports to the submarine in the first four moves of the game.

Blue may alter physical positioning for ships in formation. See Fig. 3. Graphic displays are furnished both sides. The Blue display screen shows only Blue platforms and the appropriate symbols in the event of a submarine detection. The submarine display identifies each Blue ship with a contact number. No unique shapes of the Blue ships indicate to the Red side their size or type. The submarine is also given a bearing to the sonar signals emitting from the Blue ships' active sonars. The signals are identified by sonar nomenclature numbers. (e.g., SQS-23, SQS-26, etc.) See Fig. 4A for a graphic illustration.

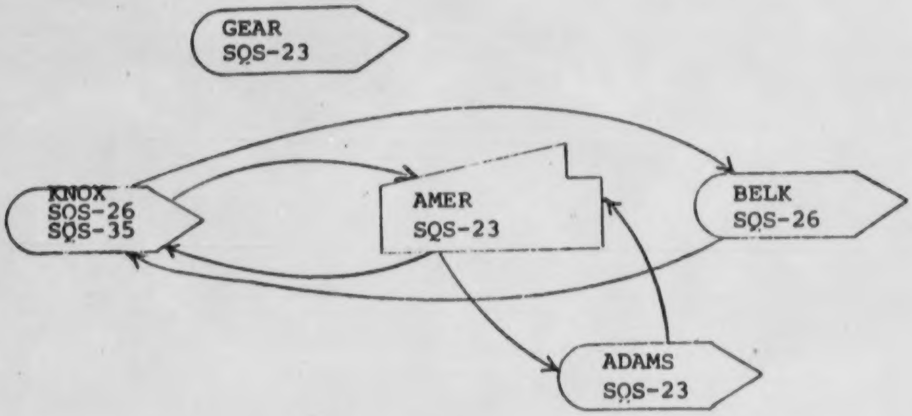


Fig. 3

STEP 3. Red side may make course, speed, and depth changes.

STEP 4. Blue side may make course, speed, and depth changes. New graphic displays update the ship positions.

STEP 5. Detection tests are activated to determine if Blue ships have detected the submarine. The submarine is not notified as to whether or not detection is made by Blue ships.

STEP 6. Red side inputs of keyword commands.

STEP 7. Blue side inputs of keyword commands.

STEP 8. If action is to be initiated, "FIRE" buttons are depressed. Action is graphically displayed and damage assessed if any.

Players return to Step 3 and repeat Steps 3-8 until game is terminated.

NOTES ON ACTION SEQUENCE

Attacks by both forces in the game take place simultaneously. Weapons committed by both players in any given move are considered to be fired at approximately the same time. A broad assumption is made that defending units will react quickly enough to counter any threat before such threats reach the defending platform.

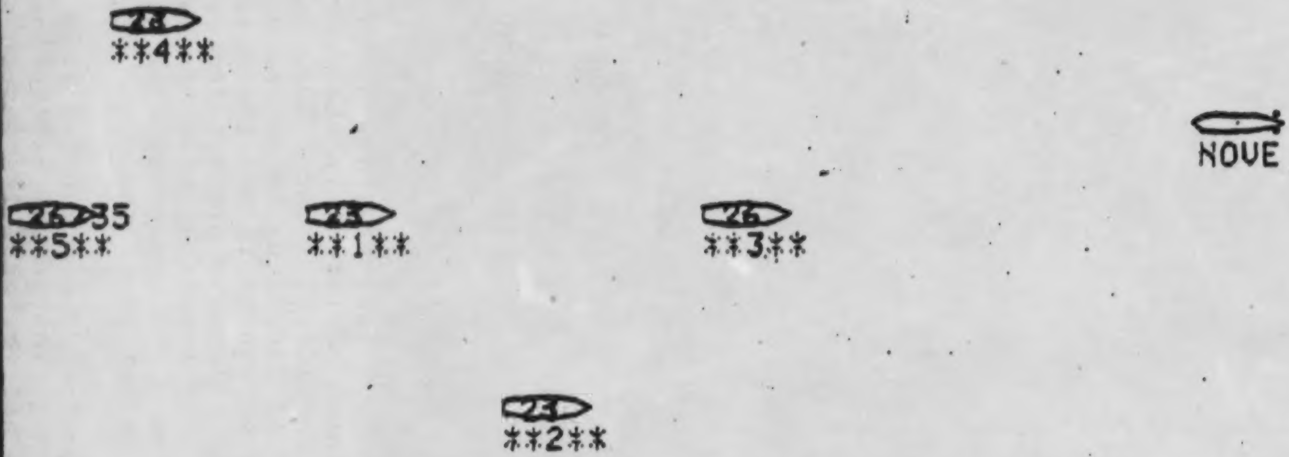
The input sequence used by the program requires the Red team to make all weapon commitments before the Blue team. "RACKET REPORTS" alert the Blue team to electronic activity which accompanies the Red weapon commitments. The Blue team then makes its weapon commitments, based on previous status and the additional electronic information. Electronics reports likewise notify the Red team of the Blue team's offensive commitments.

The results of both forces' actions are then analyzed. Weapons of relatively low speed, which do not reach their intended target in the course of a single move, are considered first. They can be launched, run out of range, or intercept a target. Defensive missile or gun shots are then examined to determine how many offensive projectiles are intercepted. Finally, the remaining offensive weapons are analyzed to determine the number of hits and extent of damage on the target platforms.

The input sequence places the Red team in a somewhat unrealistic position in some situations. Since the Blue team has not yet made its weapon assignments, the Red players do not have the benefit of "RACKET REPORTS" on which to base their defensive actions. They must anticipate Blue offensive actions and make

RED DISPLAY SUBMARINE VS SURFACE

THERMAL LAYER DEPTH = 250 FT


4
35
5
1
3
NOVE
2

ASW SCENARIO
(RED DISPLAY).
FIG. 4A

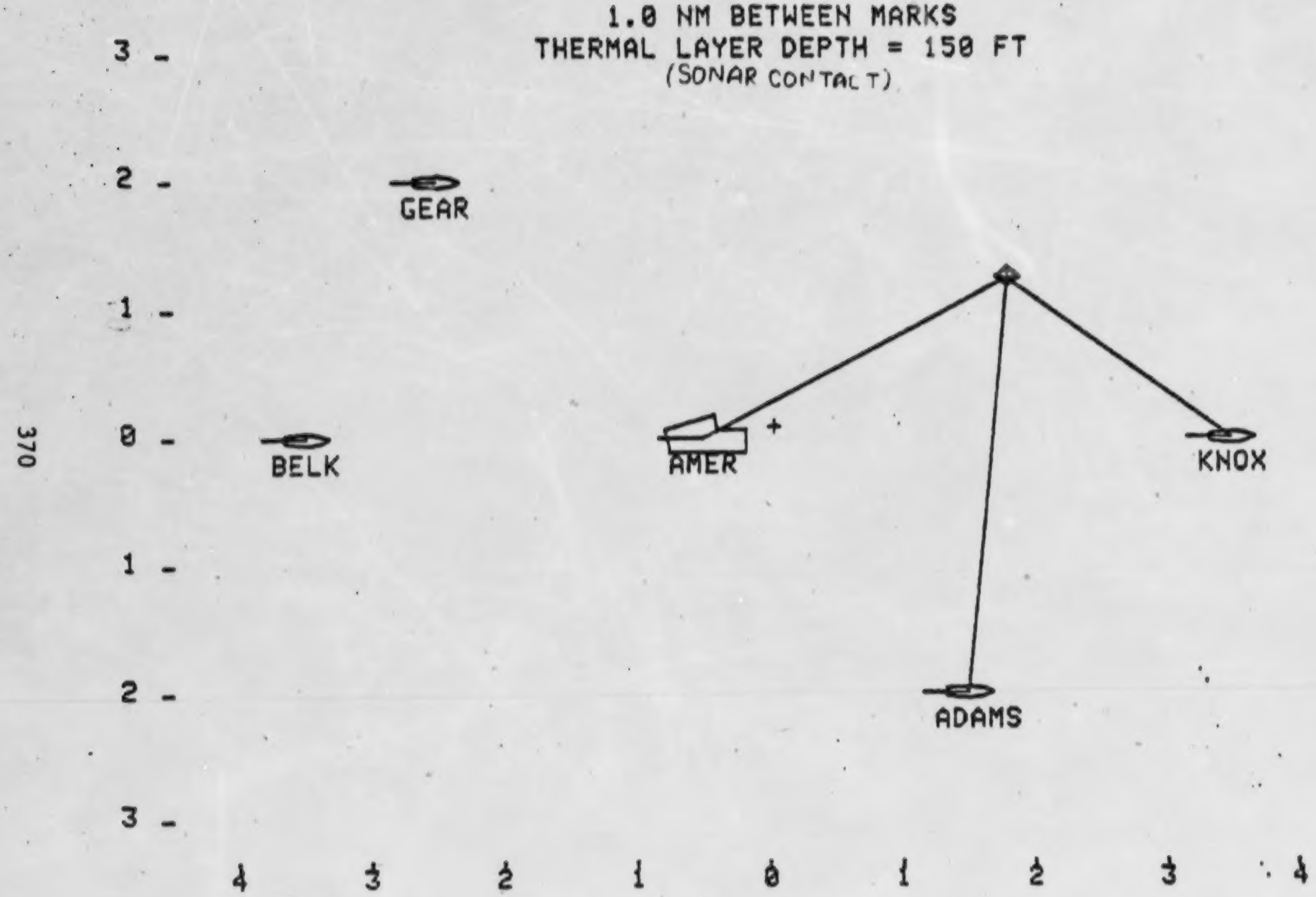

1.0 NM BETWEEN MARKS
THERMAL LAYER DEPTH = 150 FT
(SONAR CONTACT)
GEAR
BELK
AMER
KNOX
ADAMS

FIG. 4B

defensive assignments accordingly. In most existing scenarios however, the Blue force is placed in a defensive posture which minimizes or eliminates any artificial advantage.

CONCLUSION

The NAVTAG computer game was introduced into the Naval Academy curriculum beginning with the Spring semester of Academic Year 1976-77. Information on the results of the effectiveness of its use was gathered through the use of student written critiques, personal interviews, observation of classes, and instructor evaluations.

In the first semester of the game's use in conjunction with class lecture material, 200 senior level midshipmen participated in course NS400, "Tactical Warfare Seminar." During the Academic Year 1977-78, 1100 senior level midshipmen participated in the same course using the computer game to support course objectives in tactical instruction. In the following summer session, a new course NS300T, "Introduction to Naval Tactical Warfare," was offered, in which 900 junior level students were given an accelerated introduction to anti-aircraft warfare, anti-submarine warfare and surface warfare. Student participation in the computer games was a large portion of this introductory course.

The number of instructors of these courses, all active duty naval officers, grew from three for the Fall semester in 1976-77 to ten in 1977-78 and then to a total compliment of twenty-one for the summer course session. The summer session instructor force consisted of officers from the Division of Professional Development and the Division of Engineering and Weapons. An increasing number of instructors was needed because of larger numbers of students, smaller class sections, and a shorter time to present the class material.

Student and instructor response to the new course format was overwhelmingly positive. 79% of course NS300T students reported that the course material, in conjunction with the computer war game, stimulated their thought processes and greatly aided their ability to acquire and retain the course information. 74% of all students taking the courses reported that they felt the courses were the most interesting professional courses at the Naval Academy. Only 16% of the students taking the courses had had any previous exposure to tactical warfare course material or terminology.

Instructor response was equally positive in that 87% of the instructors who taught the courses volunteered to repeat their teaching assignments in the future. Instructor personnel from the Division of Engineering and Weapons reported that the teaching methodology used in the tactical warfare courses was practical and effective and had definite potential for application in certain engineering and weapons courses.

The NAVTAG wargaming system has been positively accepted by students, instructors, and Naval Academy educators involved with its use. It has proven to be a very effective teaching tool by employing a method of multiple presentation of information to the student, thereby promoting learning in a "painless" and exciting manner. In this case, computer-assisted instruction has proven to be the "better way" for presentation of course material, stimulating interest, and utilization of knowledge, all spiced with the important ingredient of entertainment.

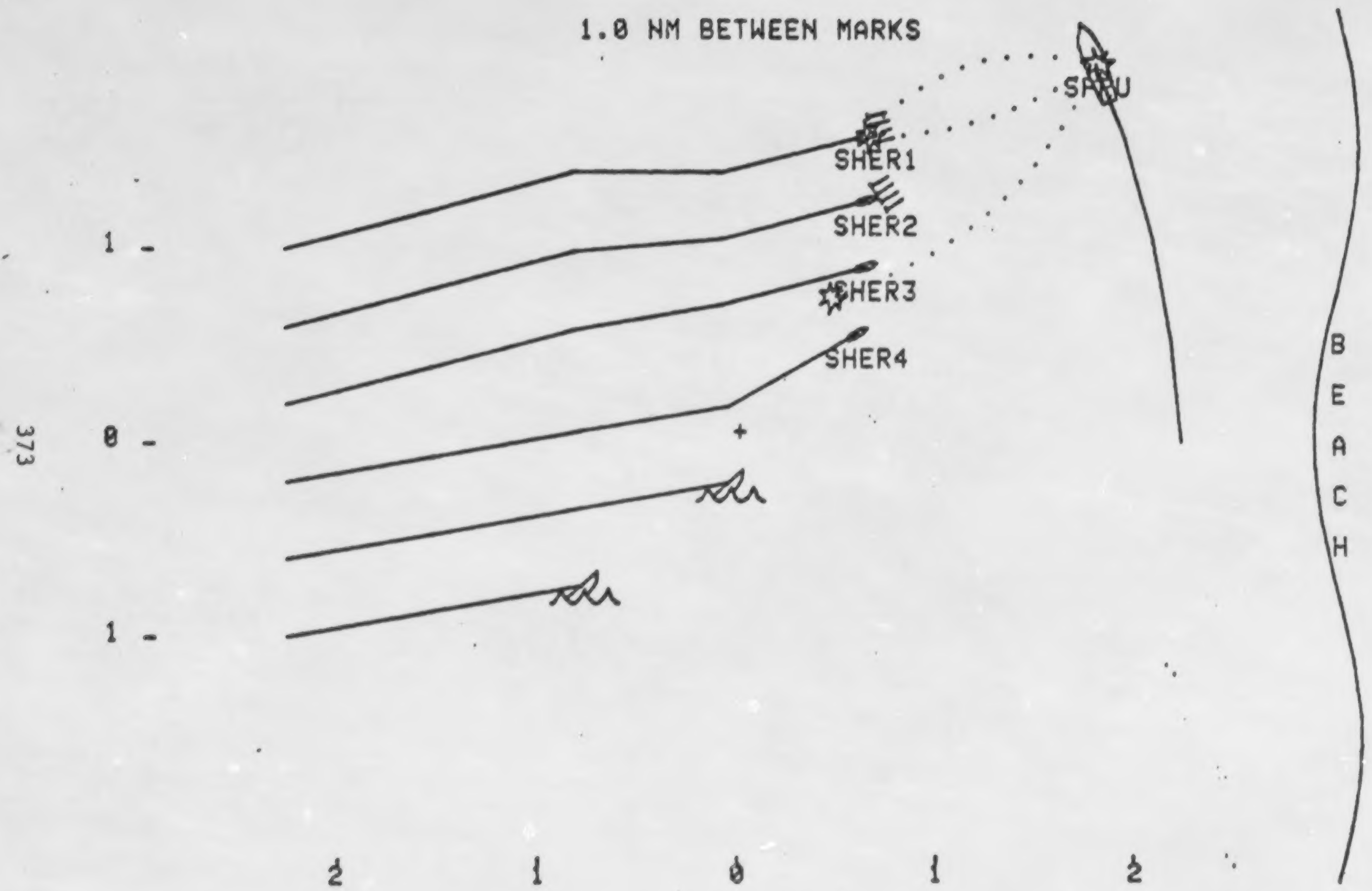

1.0 NM BETWEEN MARKS
SPRU
SHER1
SHER2
SHER3
SHER4
B
E
A
C
H
1 -
0 -
1 -
373
2
1
0
1
2

FIG. 5

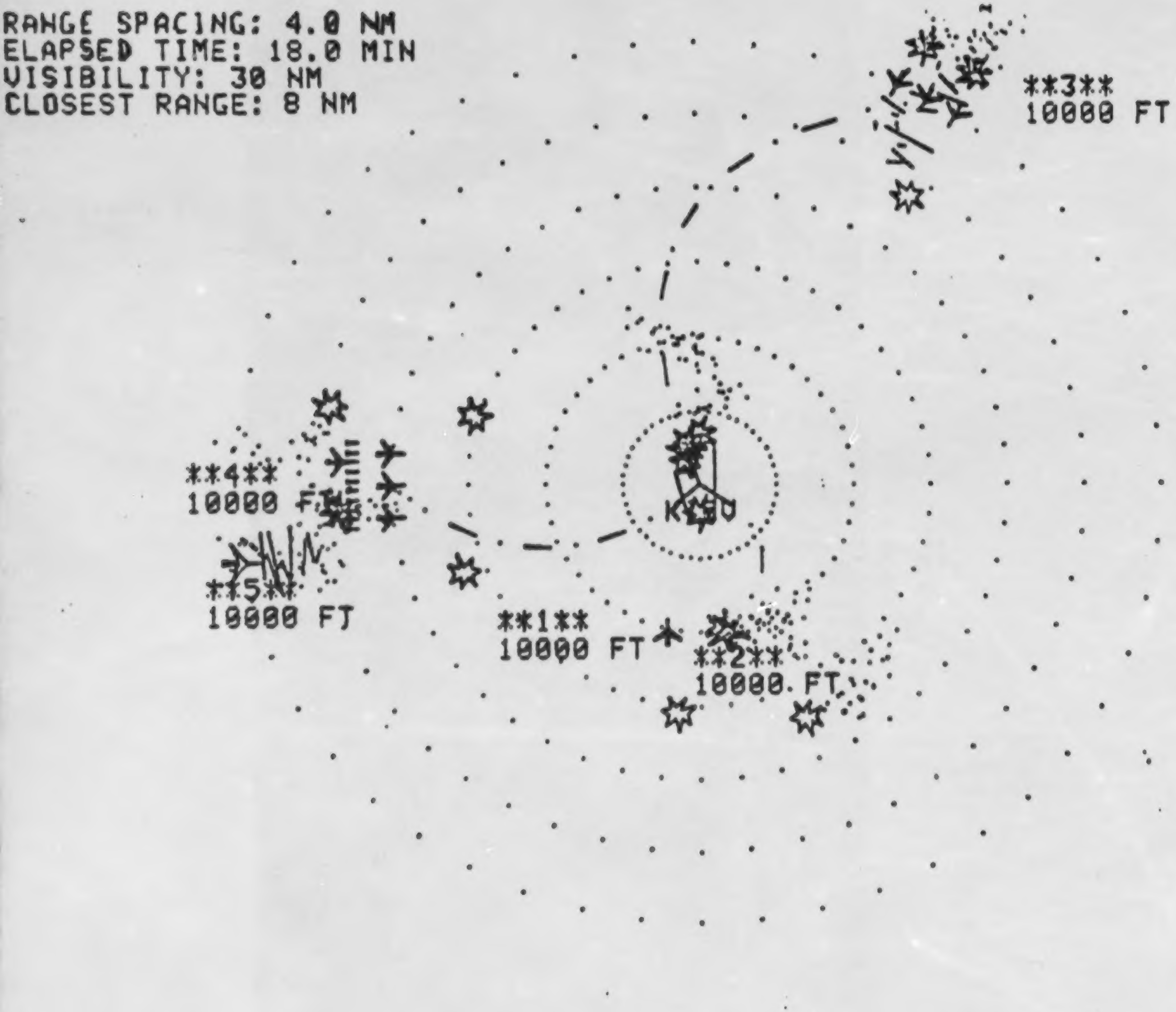

RANGE SPACING: 4.0 NM
ELAPSED TIME: 18.0 MIN
VISIBILITY: 30 NM
CLOSEST RANGE: 8 NM
3
10000 FT
4
10000 FT
KNSO
5
10000 FT
1
10000 FT
2
10000 FT

FIG. 6

3-D Display of Kiev vs Aircraft

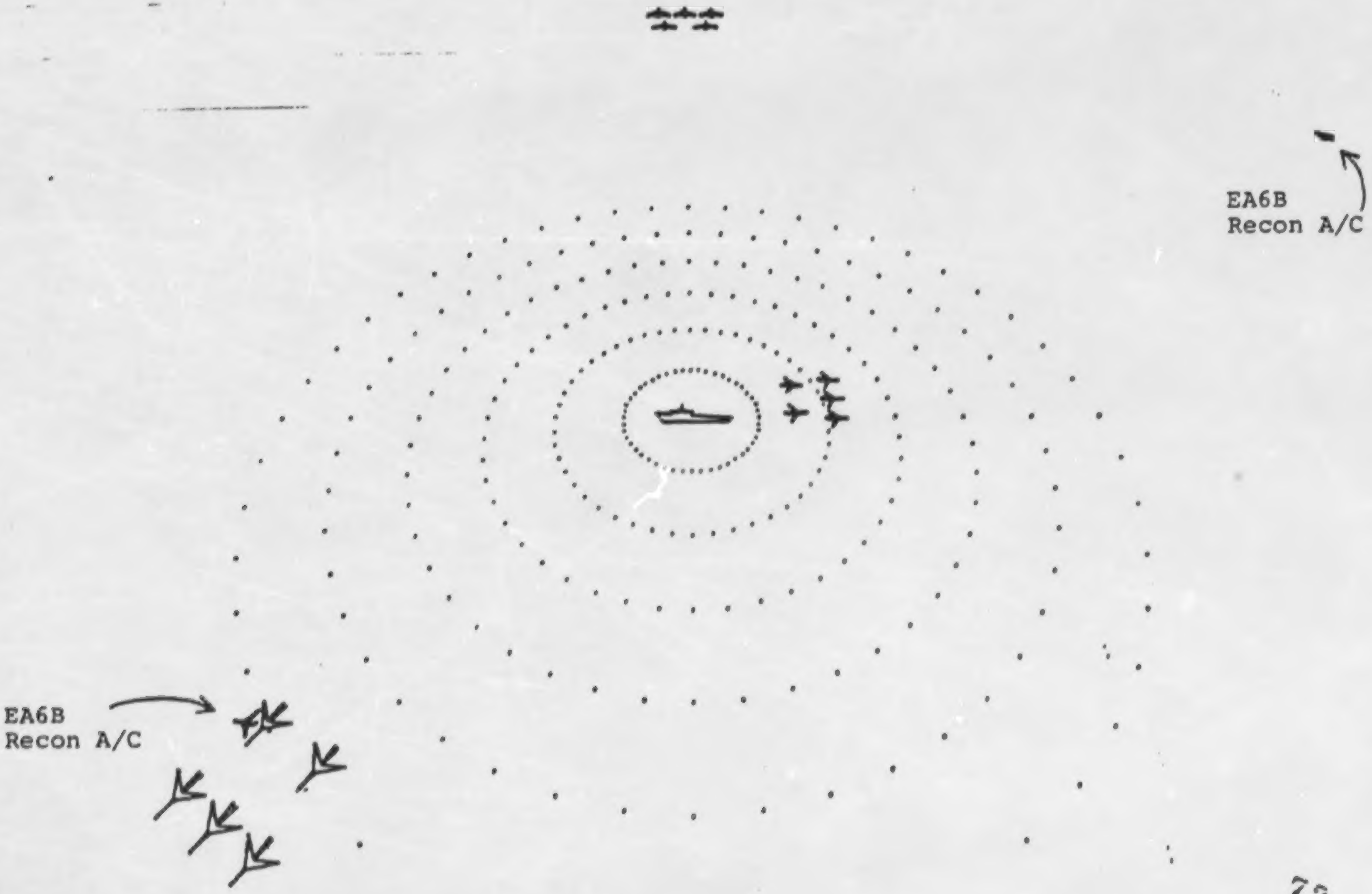

EA6B
Recon A/C
EA6B
Recon A/C

FIG. 7

Angola Surface vs Surface Action

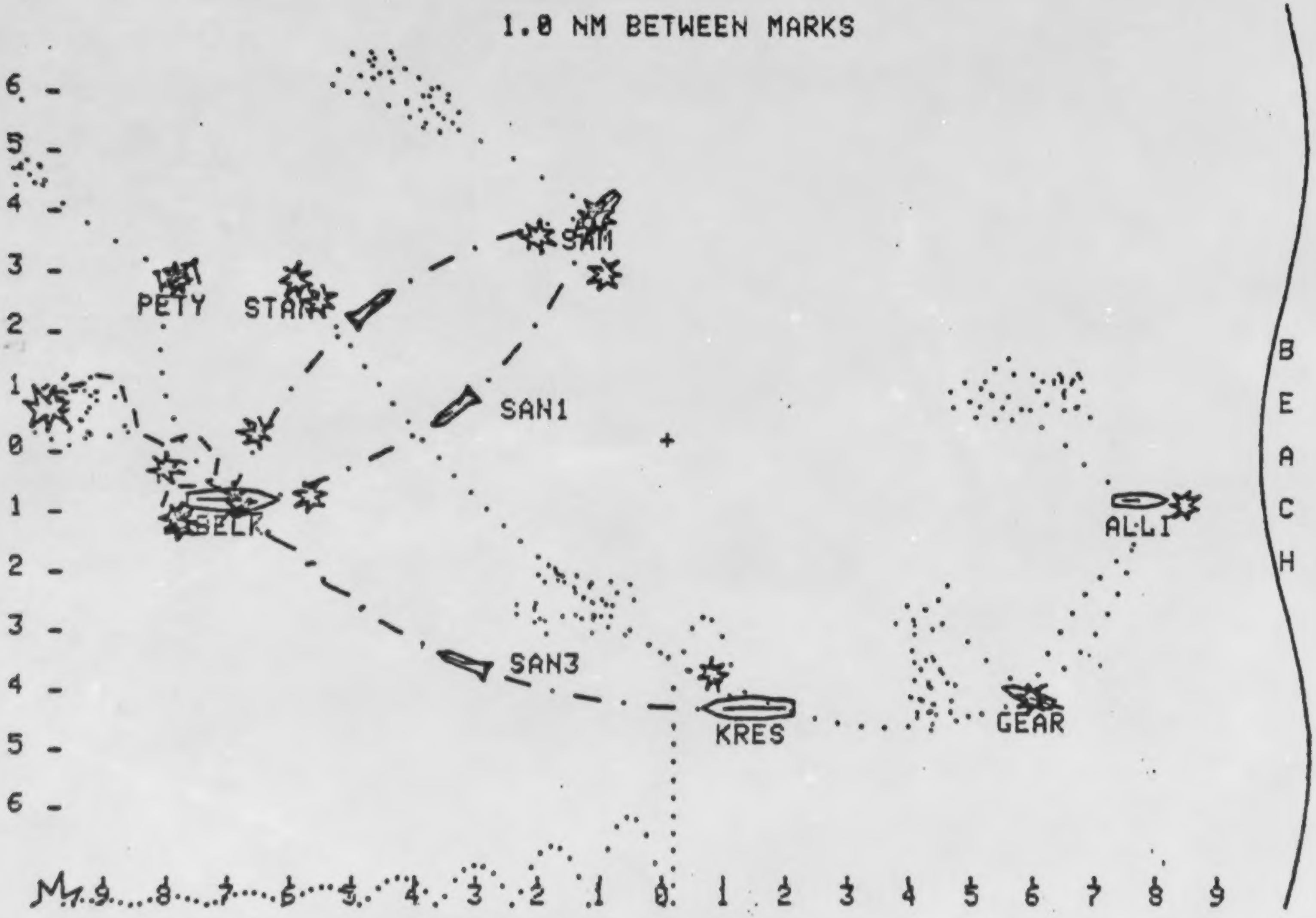

1.0 NM BETWEEN MARKS
6
5
4
3
2
1
0
1
2
3
4
5
6
PETY
STAR
SAM
SAN1
SELK
SAN3
KRES
GEAR
ALLI
B
E
A
C
H
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9

FIG. 8

A Computer-based Study Guide for Aviation Certification

Stanley R. Trollip

Certification in general aviation usually requires the applicant to pass both a written examination and flight test. The written section covers such topics as knowledge of the flight regulations, navigation techniques, and emergency procedures. The flight check covers aircraft handling in both normal and abnormal situations.

The current Federal Aviation Administration Written Test for the Private Pilot Certificate is a 60 item test drawn in pseudo-random fashion from a pool of 700 questions. There are several forms of the test at any one time, and the minimum passing grade is 70% or 42 items correct.

The Federal Aviation Administration (FAA) recently published 600 of these 700 questions in a book called the Private Pilot Written Examination Study Guide (FAA, 1977). The purpose of this publication is to help students prepare for the written examination by practicing the same types of question that appear on the Written Examination.

There are problems, however, in using the Study Guide effectively. First, the questions are not organized in any way, making it impossible for the student to pinpoint weak areas easily. Second, because of the lack of order it is difficult to concentrate on known weak areas. Third, it is cumbersome to turn to the back of the book each time to determine the correct answer. Finally, many students have difficulty in learning from a resource like the Study Guide. They say they cannot maintain their concentration.

In an attempt to solve some of these drawbacks the Aviation Research Laboratory at the University of Illinois incorporated the questions into a computer-based Study Guide implemented on the university's PLATO (Alpert and Bitzer, 1970) computer system.

Implementation

The 600 published questions were cross referenced to 17 major categories containing a total of 124 sub-categories. This classification scheme is the one used by the FAA to reference all the areas of knowledge it deems necessary for students to cover for the Private Pilot Test. These questions were then input into the PLATO system as a Study Guide which offered the following options:

1. A quiz of indefinite length (up to 600) generated in such a way as to guarantee maximum coverage of the subject matter. This option can be terminated at any time, at which the results are given and a list of sub-categories printed in which the student has exhibited weakness.

2. The student can choose to have a quiz generated from any one of the 17 major categories. Once again the item sampling ensures maximum coverage of the material. This option allows students to concentrate on major areas of weakness.

3. This option affords the greatest flexibility by allowing the student to construct an item pool from any combination of the sub-categories.

A recommended procedure is for the student to enter option 1, answer about 50 questions, obtain the results and view the printout of sub-categories in which weakness has been demonstrated. The student then transfers to option 3 where the system has tagged those sub-categories listed in option 1, and recommends further study on them.

It should be noted that in this form the program offers no instruction or remediation. All it provides is an ordered way of sampling from the FAA question pool, instant feedback as to the correctness of the answer, and the ability to select questions from specific subsets of the question pool.

In another program the Study Guide has been incorporated into a computer-managed sequence. Subcategories are grouped together so that each group forms the basis of a one week study requriement. In total there are 32 groups corresponding to each week in the two semester Private Pilot curriculum at the Institute of Aviation. In this program weekly assignments are prescribed including readings, worksheets, slide/tape presentations and films. A weekly quiz has to be passed before progress may be made to the next assignment.

Evaluation

The discussion of the evaluation of the Study Guide is divided into four parts: the usage of the program, some empirical comparisions, student feedback, and side benefits. All of these contribute in some way to the final evaluation, although it is difficult to ascribe weightings to each.

In the discussion, reference will be made to three groups of students. The first, Group I, was comprised of 83 students enrolled in the second course (AVI 120) of the Private Pilot syllabus during the Spring semester of 1978. Group II was one section of the 1978 Fall semester AVI 120 course, while Group III was the other section of that course. Groups II and III each had 25 students.

Usage: The Study Guide was implemented five weeks before the end of the Spring semester 1978. PLATO signons were given to all students in Group I, to 35 students enrolled in a similar course at Parkland Community College in Champaign, Illinois, and the program was listed on a general aviation index maintained on PLATO. In these five weeks the program was used over 700 hours with an average of 35 minutes per use.

During the Fall semester 1978 all students enrolled at the Institute of Aviation (about 275) were given PLATO signons, and the lsiting in the general aviation index was maintained. During this semester approximately 800 hours of use were recorded with an average use of just over 25 minutes.

Although use of the Study Guide was not mandatory, all three groups knew that their final examination would be a 75 item test drawn from the 600 question pool. This provided motivation for the students to make use of the Study Guide. Of the total hours spent on the program, Institute of Aviation students accounted for 73%, Parkland students 22%, and the remaining 5% came from other PLATO users.

Comparisons: Although no strictly controlled study has been conducted to investigate the effectiveness of the Study Guide, other data are available which provide indications thereof.

Groups II and III may be regarded as experiimental groups differing in their exposure to the PLATO material. Group II was told at the beginning of the semester that the final examination would be on PLATO, and was given unlimited access to the Study Guide. Group III students also knew at the beginning of the semester about the PLATO final, but were required to pass weekly quizzes based on the computer-managed program described above. In addition to the final examination, both Groups took two written tests during the semester. Table 1 shows the performance on the tests and final examination by Group.

TABLE 1

Group performance on the written tests and final examination

	First Test	Second Test	Final
Group II	20.20	40.40	69.88
Group III	21.10	42.73	72.76
Maximum score	25	50	75

On both the second test and the final examination, Group III performed significantly better than Group II (p=.032 for second test, p= .011 for final). The difference on the second test, which was a written one, suggests that the time spent on PLATO positively affected performance on other areas, such as airplane performance data and weather, topics not well covered by the Study Guide but included on the test. However, much of the difference on the final results must be attributed to the different time each Group spent on PLATO during the semester (6.8 hours for Group II, 16.7 hours for Group III).

Notwithstanding the confounding effects of time spent on PLATO on performance, the fact that the Group III students ended up doing better than their counterparts is encouraging. It confirms many previous findings that distributed practice is better than "cramming". Both groups spent approximately the same time on PLATO during the last week (3.1 hours for Group II, 2.7 hours for Group III). This represented 46% of Group II's total PLATO contact time, and only 16% of Group III's.

In addition, both Groups performed significantly better on the final than had Group I the previous semester ($p<.001$ for both comparisons).

Student Feedback: Feedback about the lesson was obtained in two ways. First, an automatic commenting capability was incorporated into the Study Guide, allowing the student at any time to write a comment to the authors of the lesson. Although this facility was used most often to point out spelling mistakes in the question pool, it was also used quite freuqently on the program. Almost without exception the unsolicited comments from these outside users were very postivie and encouraging.

Second, a questionnaire was given to all students in Group III asking them to comment on the positive and negative aspects of their PLATO exposure. Of the 21 respondents all but one were positive about the program; the one dissenter found that the location of terminals and occasional system failures took too much time to make the program attractive. The two most common complaints were that terminals were not conveniently located, and that many of the questions were repetitious. This latter point is true and is indicative of some of the faults inherent in the question pool.

Side benefits: The ready availability and easy access to the Study Guide has had various side benefits. First, the automatic commenting ability resulted in users indicating which questions were ambiguously worded or badly written. In a book-based system the rectification of such ambiguities is virtually impossible. (Actually the FAA occasionally mails out little strips of paper to be pasted in all its test booklets, reflecting improvements in question wording.) On a computer-based system a single change affects all users immediately.

Second, an online item analysis allows for the rapid improvement of the distractors to each question. Once again the updating of a book-based system is impossible. Third, by attracting pilots or student pilots to the system for the purpose of flight certification, one can make them more comfortable with the idea of computer-based education. It provides a type of computer literacy that should be most valuable in the future. Finally, the system tends to encourage students to become involved in the process of producing aviation materials, a situation that is beneficial to all parties concerned.

Conclusion

The Private Pilot Study Guide program is one of a group of PLATO programs used at the Institute of Aviation. These programs range from complex simulations (Trollip, in press) in which the student interacts continuously with the computer, to the Study Guide described in this paper.

Work is currently underway to compuerize the Instrument, the Commerical, and the Flight Instructor Study Guides. When complete this will provide a data base of approximately 300 questions. By embedding these in a single master index the problem of repetitious questions will be reduced, and the usefulness of the system broadened.

Although none of the various aspects of the evaluation are sufficient to make strong statements about the effectiveness of the Study Guide, taken together they indicate that the program has been useful and well received. Overall, the automated Study Guide has resulted in an increased appreication of the role of computers in aviation training, and a heightened interest in the Ground School aspects of pilot certification.

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Federal Aviation Administration. Private Pilot Written Examination Study Guide. Washington, D. C.; United States Government Printing Office, 1977.

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Acknowledgements

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RESULTS OF ONE YEAR OF COMPUTER-BASED INSTRUCTION AT THE UNITED AIRLINES FLIGHT OPERATIONS TRAINING CENTER

Charles Buchanan
United Airlines

The objective of this report is to compare the projected savings of using CBT (Computed Based Training) to conduct training for newly hired pilots to the results of that application.

The United Airlines Flight Operations Training Center, located in Denver, Colorado, is a central facility responsible for all training of United Airlines' 5,500 pilots. The largest activity is Transition Training which qualifies pilots when they move from one airplane type to another. In addition, semi-annual Proficiency Training, semi-annual Proficiency Checks, Recurrent Training, Requalification Training, Emergency Procedures Training for both pilots and flight attendants and New Hire training is conducted continuously.

All training programs are designed, produced and administered by the Flight Training Center within the organization shown in Figure 1.

The Flight Training Program Development group was charged with the responsibility to develop a training program for newly hired pilots in November of 1976. Specifically, the charge was to develop training that would assure that any newly hired pilot would be able to enter any of the regular Transition Training programs prepared to meet the objectives of that program with no modifications to the Transition Training program. This meant that new pilots must be brought up to the entry level of knowledge on which the Transition Training programs are based. To compound this problem the expectations of the availability of pilot candidates and the qualification standards for selection led us to expect a wide range of student experience in each class from the very beginning. We could expect students with experience ranging from light airplane time to those with extensive multi-engined jet experience from the military.

Based on prior research and investigations, the Flight Training Program Development group felt this situation called for the application of CRI (Criterion Referenced Instruction) principles.

A Computer Based Training Proposal was presented to the Senior Vice President of Flight Operations in May of 1977 and subsequently adopted. The conclusions and recommendations of that proposal as they apply to the New Hire Training program were:

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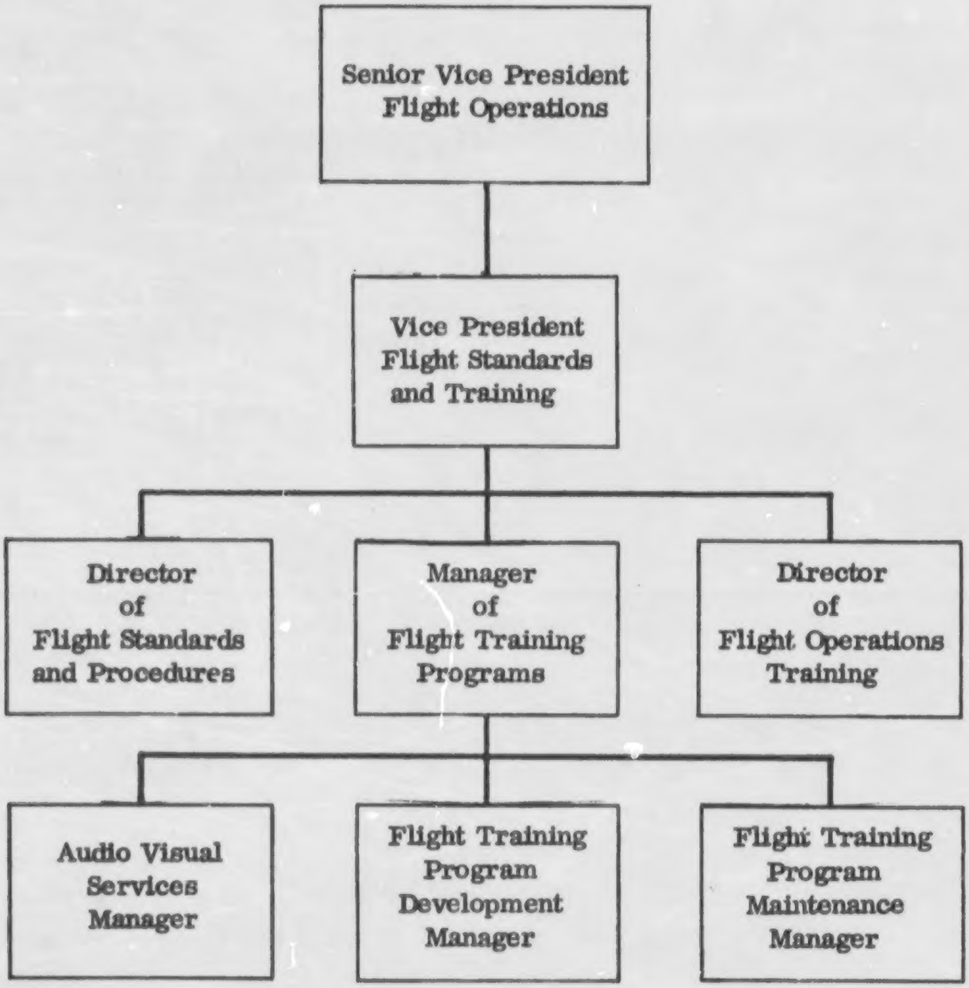

Senior Vice President
Flight Operations
Vice President
Flight Standards
and Training
Director
of
Flight Standards
and Procedures
Manager
of
Flight Training
Programs
Director
of
Flight Operations
Training
Audio Visual
Services
Manager
Flight Training
Program
Development
Manager
Flight Training
Program
Maintenance
Manager

FIGURE 1

8

Conclusions

> "Computer Based Training has evolved to the point where United Airlines Flight Standards and Training should conduct a practical evaluation of its utility through direct application to real training needs. The evaluation should be conducted in the Flight Training Center environment as part of the operational training activity."

Recommendation

> "United Airlines Flight Standards and Training should lease the PLATO Computer Based Training System from Control Data Corporation in order to accomplish the evaluation."

Rationale

There were several factors stated to support the recommendation to implement CBT:

> "Individualized Instruction is the key to providing qualified flight crew members at the least cost, and CRI is the key to individualization.
>
> Computer Based Training is essential, because it appears to be the only effective way to implement Criterion Referenced, Individualized Instruction in the flight crew training environment."

The principles involved in this type of training were described by United Airlines in a paper presented to the International Air Transport Association's Fourth General Flight Crew Training Meeting, Lucerne, Switzerland in November of 1976:

> "United Airlines Flight Operations Training has learned a great deal about the application of the Systems Approach to Training from our earlier efforts. We are convinced now that criterion tests play a much bigger part in training design than we previously appreciated. In fact, United Airlines Flight Operations Training believes that

> evaluation should control training content. Past practices have indicated that any success or failure in controlling training content has ultimately been dependent upon evaluation. There is no reason to expect this fact to change. We believe this understanding can be used to help improve training efficiency.
>
> "An understanding of the rationale for evaluation as control of training content is essential. The premise is:
>
>> 'The only basis on which to judge trainees to be ready for the job is their successful performance on criterion tests. The tests specify what the trainee must do, in a training situation, to meet the performance standard. These documented tests are agreed to by all concerned parties.'
>
> "An acceptance of this principle allows the content of training to be as much or as little as a particular trainee needs to help him master the criterion tests. The number of hours a trainee might spend in training, or the amount of information he or she is exposed to, should have no effect on what he or she would be held accountable for. The potential impact on training time becomes readily apparent."

The need for a CBT system was addressed:

> "The necessity for a Computer Based Training system over a manual system (to administer a CRI program) is dictated by the complexity of the training task and the necessity for a very high degree of control over our 'end product,' a qualified flight crew member. Errors in record keeping of performances on criterion tests cannot be tolerated in our environment. All parties (Company, FAA, Instructors and Flight Crew Members) must be assured of complete satisfactory performance on all criterion tests."

An additional reason for the acquisition of a CBT system was included:

> "Wide variations exist in experience levels in New Hire selectees as well as in lower seniority transition programs. An individualized program, suitably lean and responsive, is

> highly dependent upon accurate and accessible records of trainee performance, prerequisite training requirements, and scheduling of staff and equipment resources. Record keeping processes for these purposes are too complex to be handled manually."

A significant point of the proposal was to enter into an evaluation of CBT by using it to meet a real training need.

> "The application of Computer Based Training should be on a real training program, rather than a research and development effort. This approach allows the Flight Training Center to realize savings for an active program while gaining experience in using the system. Sufficient information exists about Criterion Referenced Instruction programs and Computer Managed Instruction to use this approach with confidence."

The CBT systems available were evaluated and PLATO was selected.

> "Leasing the PLATO system allows the Flight Training Program Development group the opportunity to gain experience with the full capabilities of Computer Based Training with minimal risk. If, after the evaluation period, Computer Based Training proves to be efficient and successful, the option to buy a system still exists.
>
> "The PLATO system can be tailored to effectively meet the training needs either by expanding or shrinking the amount of capability. The capability of use can be modified with 30 days notice. If a different system were purchased, requiring a major commitment of funds, there is little flexibility."

The application of the PCMI (PLATO Computer Managed Instruction) system was ideally set up to conduct our application for newly hired pilots. The proposal included this summary of the program:

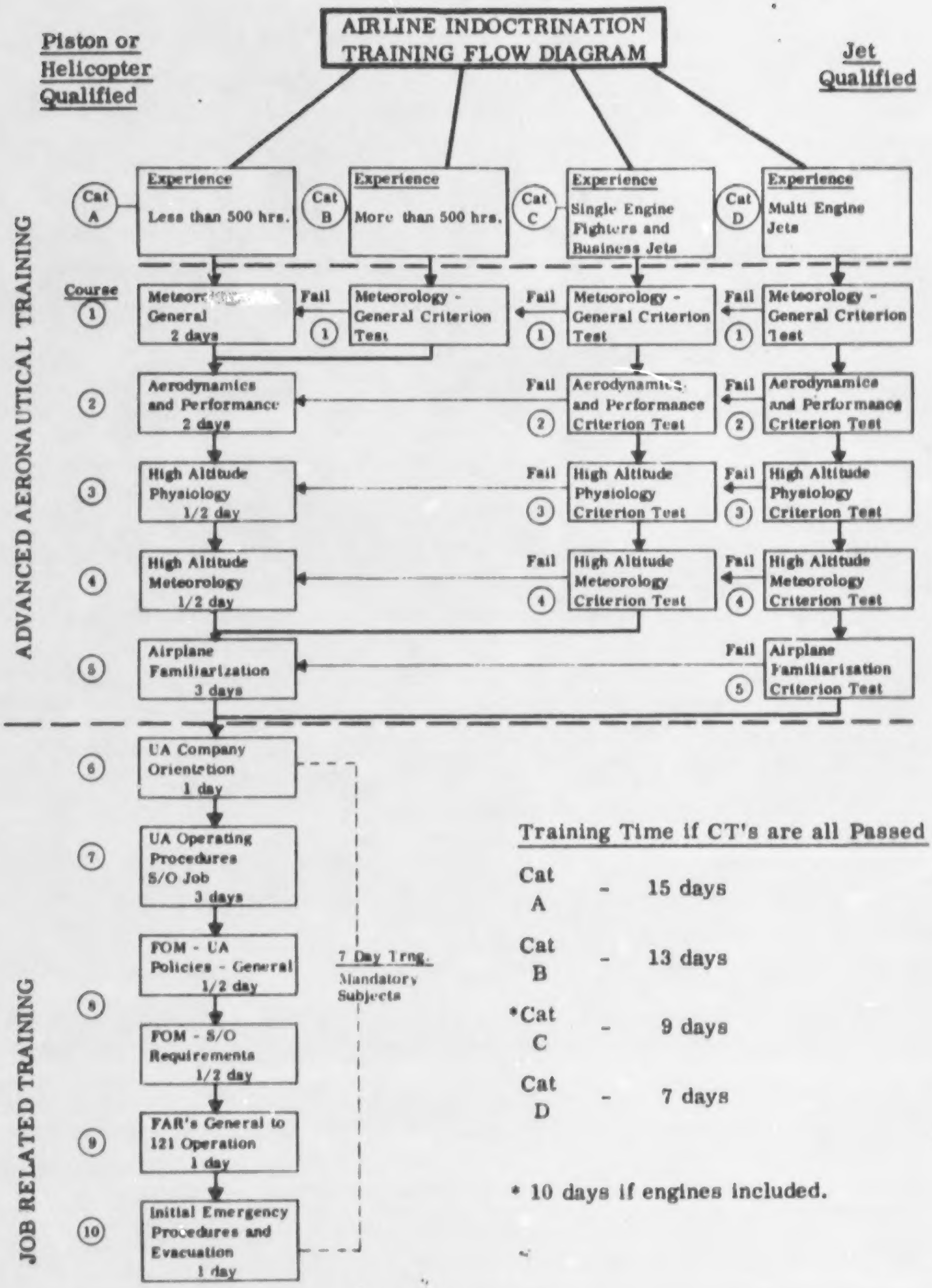
> "The New Hire Pilot Training program titled 'Advanced Aeronautical Training and Job Related Training,' will be a criterion based program designed to recognize and

> evaluate previous aeronautical knowledge and experience possessed by the pilot. Training will consist of a number of courses, such as Meteorology, Aerodynamics, Federal Aviation Regulations, Company Operating Requirements, etc. Each Module will be broken down into Instructional Units such as Atmosphere and the Affects of Heat and Moisture, Stability and Cloud Formation, Static and Dynamic Stability, Flight Characteristics.
>
> "To complete a course, all trainees must satisfactorily complete a Criterion Test that will demonstrate mastery within prescribed parameters for that particular course. If the trainee possesses required knowledge and experience to pass the Criterion Test without taking the training first, he may do so and save training time normally required to complete the course."

When training was conducted for newly hired pilots the last time, over eight years ago, the program was four weeks long. It consisted of twenty days of traditional instruction covering generally the same materials planned for the new program. Those days were mostly classroom work for about six hours per day. Four weeks was conceded to be the time it would take to do the same job today if we were to use traditional methods.

Since there was a commitment to apply CRI principles to this new program, estimates were made on the times that various categories of students, based on type of experience, as to the time of training expected for each category. Our estimates showed a range of seven days for multiengined jet experienced pilots to fifteen days for experience of less than 500 hours of flying time.

Figure 2 shows the basis for those estimates.


AIRLINE INDOCTRINATION TRAINING FLOW DIAGRAM
Piston or Helicopter Qualified
Jet Qualified
ADVANCED AERONAUTICAL TRAINING
JOB RELATED TRAINING
Cat A
Experience Less than 500 hrs.
Cat B
Experience More than 500 hrs.
Cat C
Experience Single Engine Fighters and Business Jets
Cat D
Experience Multi Engine Jets
Course
1
Meteorology - General 2 days
Fail
Meteorology - General Criterion Test
2
Aerodynamics and Performance 2 days
Aerodynamics and Performance Criterion Test
3
High Altitude Physiology 1/2 day
High Altitude Physiology Criterion Test
4
High Altitude Meteorology 1/2 day
High Altitude Meteorology Criterion Test
5
Airplane Familiarization 3 days
Airplane Familiarization Criterion Test
6
UA Company Orientation 1 day
7
UA Operating Procedures S/O Job 3 days
8
FOM - UA Policies - General 1/2 day
FOM - S/O Requirements 1/2 day
9
FAR's General to 121 Operation 1 day
10
Initial Emergency Procedures and Evacuation 1 day
7 Day Trng. Mandatory Subjects

Training Time if CT's are all Passed

Cat A - 15 days

Cat B - 13 days

*Cat C - 9 days

Cat D - 7 days

* 10 days if engines included.

FIGURE 2

Another aspect of the proposal indicated the value of the data generation aspects of CRI that would be very helpful in the validation of learning resources:

> "....The Computer Managed Instruction system will generate a variety of statistical records to allow an author to determine the effectiveness of the various learning resources. With the ability to identify specifically which learning resource is not doing the job it can be revised and revalidated. This capability provides the opportunity and the responsibility to be fully accountable for the effectiveness of each learning resource.
>
> "For example, an instructor feels that information should be added to a course for which he is responsible. This feeling may come from a variety of indications, some valid and some not. But, with trainee performance data available showing satisfactory performance on the particular set of criterion tests, for the objectives covered by the author's course, we can show why the course should not be lengthened. This will help keep the training program from growing without proper justification. And, a shorter course that still meets the objectives means lower costs. Accountability for the effectiveness of learning resources will help manage training costs more effectively."

Armed with the previously stated principles and base assumptions a cost/benefits analysis was presented for the New Hire program:

> "$29,827.00 Savings in First Year of New Hire Program
>
> PLATO Computer Based Training including the course development work, Computer Based Training System training and Instructor training, and one year of operation results in a savings of $29,827.00. This savings is based on an average annual requirement for 367 trainees beginning in January 1978. This indicates that to establish the PLATO Computer Based Training system and use it for Computer Managed Instruction of the New Hire training program actually saves money with the first year's trainees. This demonstrates the value of applying the technology to a

> real training need to evaluate it in the flight training environment as opposed to a straight research and development effort. Cost reduction exceeds costs after 15½ months."

The cost savings were calculated as shown in Figure 3.

NEW HIRE TRAINING PROGRAM

Figures Based On:

Trainee Salary	$1,000. per month
FOI Salary and Benefits	$2,395. per month
No. of Trainees	367 per year

WITHOUT PLATO		WITH PLATO	
15 Days per Trainee	$253,964./Yr.	11 Days per Trainee	$136,069./Yr.
7 FOIs	$201,180./Yr.	5 FOIs	$143,700./Yr.
		PLATO Costs	
		Pre-training Costs PLATO Lease and Communications	$ 25,844./Yr.
		1 Year of Training PLATO Lease and Communications	$ 69,704./Yr.
TOTAL	$455,144./Yr.	TOTAL	$425,317./Yr.

With PLATO, costs are $29,827. less after one year of training.

FIGURE 4

Figure 4 shows cost versus savings based on proposal estimates.

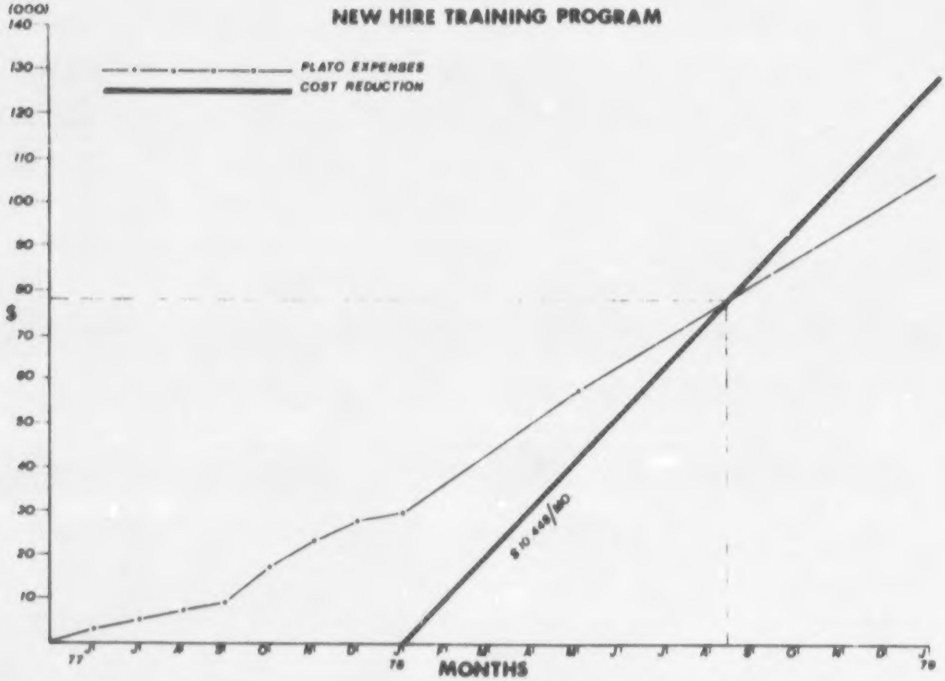


FIGURE 4

It is important to note that there are no costs allocated to the development of the training program materials. Because there was a commitment to a CRI approach whether we acquired a CBT system or not it was apparent that the development costs would be similar so they were not assigned to the cost of the CBT system.

As is often the case, our plans didn't match what actually happened.

In the first place we had more students than we anticipated. We had planned for 367 students for the year and by the end of October there had been 360 students in the program. Figure 5 shows those figures.

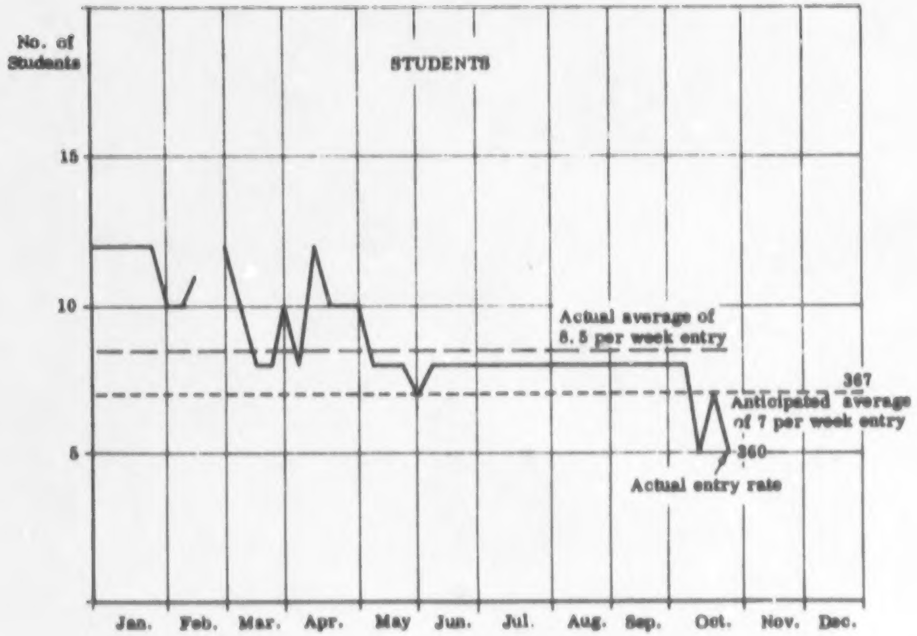


FIGURE 5

A worthwhile benefit of the CBT system is that we were able to handle a variable student entry rate without adding any instructors and were able to vary PLATO resources to match our needs. These factors contributed favorably to our costs.

Our proposal stated that a manually run CRI program would result in an average of 15 days in training. We estimated the average to be 11 days with a CBT system. The actual result was an average of 9.6

days. (The actual average does not take into account any fractional days, i.e., even though a student only had to master one criterion test the last day, it was counted a full day.) See Figure 6.

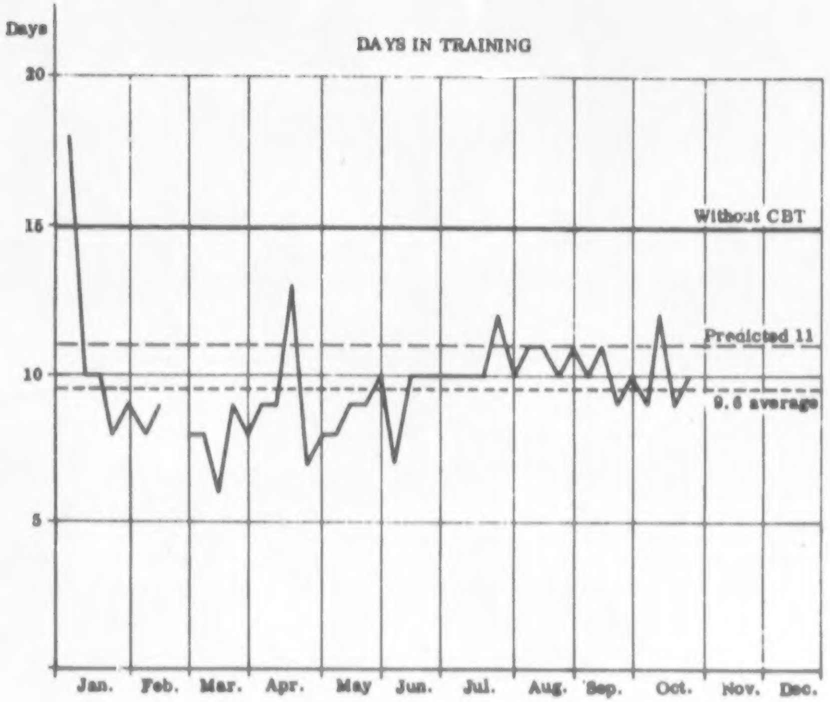


FIGURE 6

Figure 7 shows the costs for student time at an average of 15 days per student and 9.6 days per student. Compared to our estimates of 11 days there was an additional savings of $22,968.

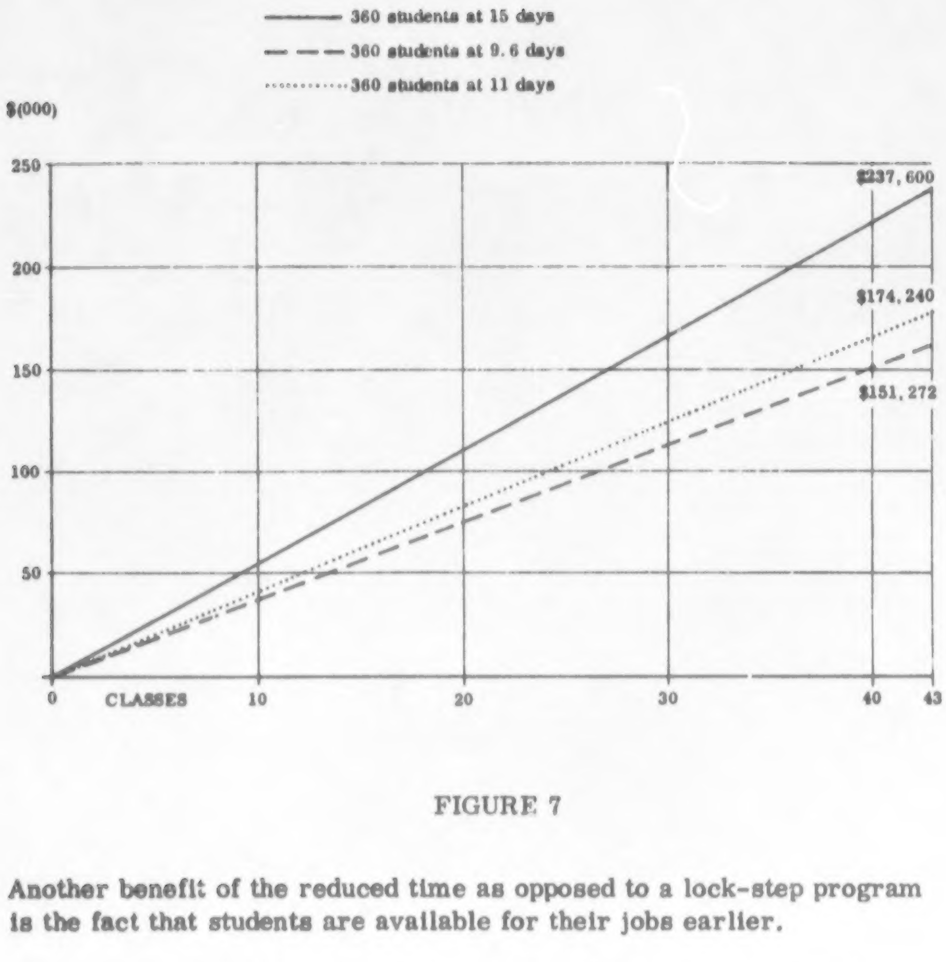


FIGURE 7

Another benefit of the reduced time as opposed to a lock-step program is the fact that students are available for their jobs earlier.

Figure 8 compares the total numbers of students that could finish training in 43 weeks according to the indicated average training times. The fifth column is the number of students who have completed all training (approximately 5 weeks in addition to the New Hire program) and are on the line as productive flight crew members. NOTE: The actual number is larger than the average-based number because many students finish the New Hire program in less than average time, some in as few as 4 days.

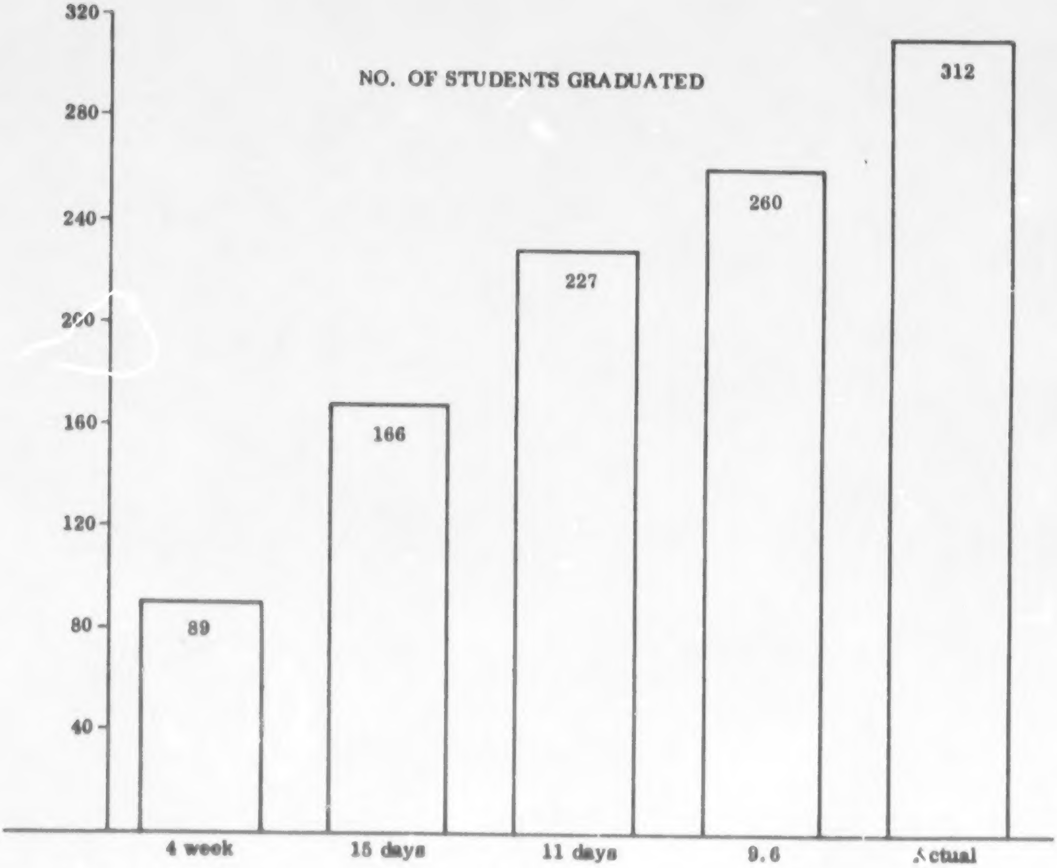


FIGURE 8

Additional savings have been realized in instructor costs. The estimated need for 7 Flight Operations Instructors if the CRI program had been administered without a CBT system is used as the basis for comparison. With a CBT system we estimated the need for 5 Flight Operations

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Instructors. Flight Operations Instructors are highly qualified people. Many are pilots with extensive experience and all have experience as licensed Flight Engineers. Most of the Flight Operations Instructors in the Training Center are qualified as a Flight Engineer on the particular airplane that they teach and do in fact maintain their qualification to operate as a flight crew member.

When the CRI was begun for the New Hire program, 3 Flight Operations Instructors were assigned to man the Learning Center to assist the students by answering their questions, helping them with PLATO and assuring the security of our tests.

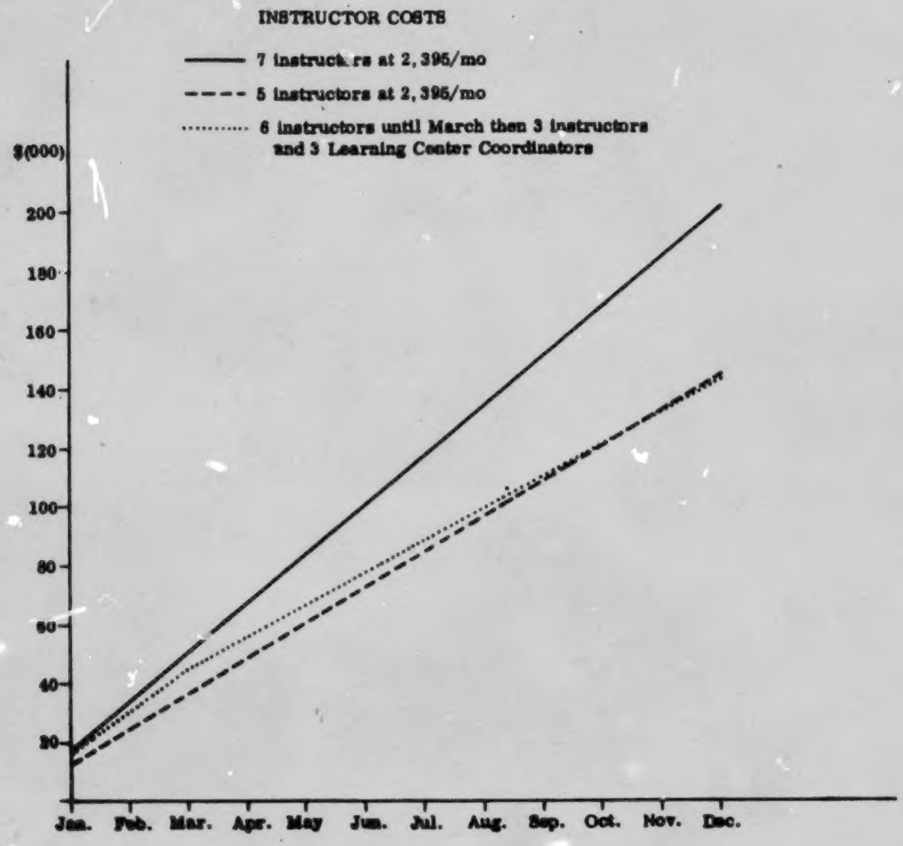

FIGURE 9

Within a few weeks the instructors asked to be relieved of their duties in the Learning Center on the basis that what they were doing could be done by clerical people. As a result the 3 Flight Operations Instructors were used in other airplane programs and 3 Learning Center Coordinators were hired to replace them at less than half the cost. Figure 9 shows the effect of that savings.

Figure 10 shows the relationship for the total cost savings of student salaries and instructor costs to the cost of having the PLATO CBT system. In 10 months a savings of $43,187. has been realized.

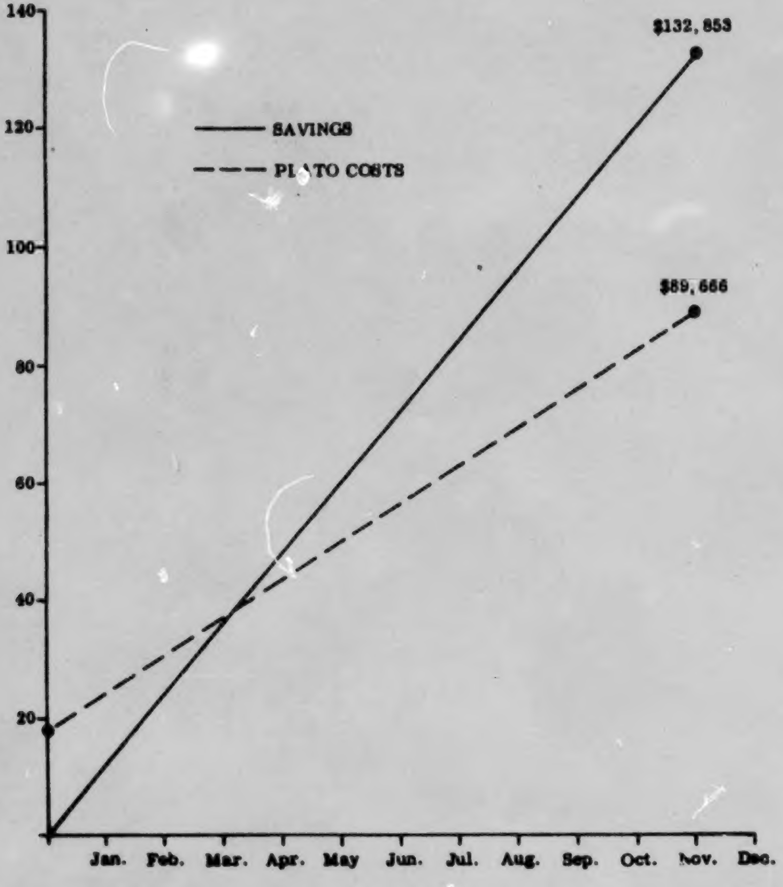

FIGURE 10

Clearly the application of Criterion Referenced, Individualized Instruction as administered with the help of a CBT system having good CMI capabilities is paying off for United Airlines Flight Training.

The figures used have been conservative to the extent that the Pilot Skills Training and Assessment portion of the newly hired pilots training has not been figured into this outcome. That program uses an average of 5 hours in a flight simulator over a period of 3 days for each student. This program was initiated after initial planning for the course was completed and was incorporated in the students training in conjunction with their working on the CRI part of the course.

It should be noted that this program does not use any CAI for learning resources. There are two program development efforts currently in progress that will use a combination of learning resources including the simulation capabilities of the PLATO system. There are two additional programs in preparation that will use the CBT system in a manner similar to the New Hire program. Each new application is evaluated and adopted if it seems to be cost effective. Our experience with PLATO has given us a sound basis on which to make these decisions. We are planning to conduct our entire Boeing 767 transition training program using Criterion Referenced Instruction with a CBT system to manage all aspects of the course from knowledge skills through exercises and practice in the airplane simulator.

EVALUATING THE USE OF INTERACTIVE, COMPUTER-MANAGED INSTRUCTION TO CONTROL THE QUALITY OF SELF-PACED TRAINING WITHOUT REQUIRING THE PRESENCE OF AN INSTRUCTOR

by

Jesse M. Heines

Educational Services

DIGITAL EQUIPMENT CORPORATION
Bedford, Massachusetts 01730

ABSTRACT

This paper describes the evaluation of a new training package on BASIC language programming. The training package consists of 16 learning modules coupled with an interactive Computer-Managed Instruction (CMI) system. The CMI system generates pretests and posttests for each of the modules in the course. The entire training package is intended to be sold to customers to be used in a self-paced mode. This paper discusses the strategies that are being employed to evaluate this approach to the quality control of self-paced instruction.

THE BASIC PRIMER: COMPONENT PARTS

The BASIC Primer is a new self-paced course on BASIC language programming. This course consists of 16 modules which cover topics from simple input/output and computations to the use of sequential and virtual array files. Each module has clearly stated behavorial objectives, text and graphics to instruct the learner on the topics being presented, and exercises to be performed both on paper and on a computer system to reinforce the concepts being presented.

Before each module, students are given the opportunity to take a pretest on that module. If they "pass" this pretest, they are instructed to go on to another module. If they do not pass the pretest, they are asked

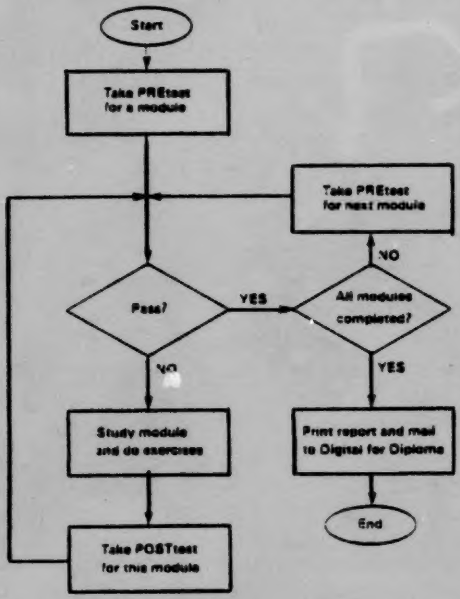
Start
Take PREtest for a module
Take PREtest for next module
NO
Pass?
YES
All modules completed?
NO
YES
Study module and do exercises
Print report and mail to Digital for Diploma
End
Take POSTtest for this module

Figure 1

INTERACTION BETWEEN ON-LINE CMI SYSTEM
AND OFF-LINE TRAINING PACKAGE

to study the module and then take a posttest. Students who pass this posttest are routed to the next appropriate module. Students who do not pass the posttest are told the numbers of the objectives on which they missed items, are asked to study these objectives again and do any exercises that they skipped, and then take another posttest. This process is flowcharted in Figure 1.

All of the tests for this course are stored on the student's own computer system. This can be a large timesharing system or a small stand-alone system. The software developed for this study is written in a subset of the BASIC language. It can therefore be translated to a variety of operating systems quite easily.

CMI SOFTWARE

The computer-managed instruction system consists of three main programs. These are the Registration Program (CMI), the Router Program (ROUTER), and the Computer-Assisted Test Administration Program (CATSTR). Two other subprograms are also included in this system: the New Student Registration Program (REGSTR) and a Feedback Program (FEEDBK). Students move through these programs as illustrated in Figure 2.

The Registration Program

The main Registration Program (CMI) does two basic things. First, it asks the user for his or her code name. This uniquely identifies each student so that the data stored on his or her work will be confidential. Second, it uses this code name to search for student-specific data in the roster file. This data includes the student's first and last names, his or her course, and the type of terminal that that student is using. If a student has not yet registered on the CMI system and selected a code name, he or she is directed to press the RETURN key without typing anything else. This causes the system to branch to the New Student Registration Program (REGSTR).

The New Student Registration Program allows students to register themselves on the system. This feature is required because the training package is intended to be used without an instructor. The students enter their terminal types, their names, and their addresses. They are then asked several demographic questions regarding their age and education and motivation for taking the course. This demographic data will allow us to look for trends in student achievement and correlate these with certain student factors.

The New Student Registration Program also produces a text file of the data that it collects from the student. Students are instructed to print this file on paper and mail it back to the course development group. These paper registration forms are kept on file for two reasons. First, it allows the course development group to send out "tickler" letters to students who have not completed the course within a reasonable amount of time. Second, it allows us to get some data on the number of students who start the course but do not complete it.

The Router Program

The purpose of the Router Program (ROUTER) is to identify the test that the student is about to take. This is not always a simple matter. The 16 modules in The BASIC Primer have specific prerequisite relationships. These prerequisite relationships are shown in the module map in Figure 3.

This module map is read in the following manner. First, one begins at the bottom. After completing Module 1, one moves up the map to Module 2. But after completing Module 2, one has the choice of studying either Module 3 or Module 4 because 2 is the only prerequisite to each of these modules. A different kind of relationship exists between Modules 12, 13, and 16. In this case, a student must complete both Modules 12 and 13 before he or she can tackle Module 16.

The Router Program has an algorithm which reads in the prerequisite modules for each of the 16 modules in the course and stores them in an array. This array, combined with the student status on each of the modules in the course, is used to determine for which modules the

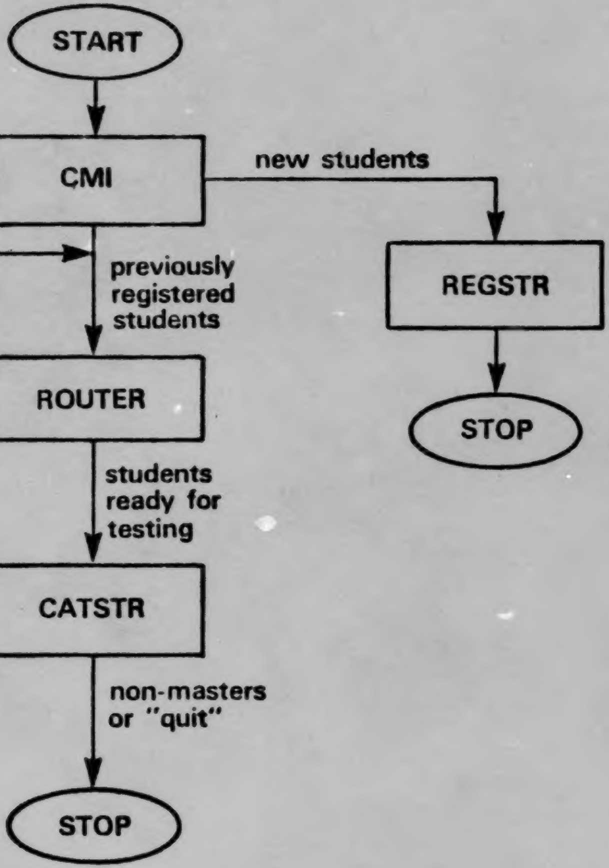
START
CMI
new students
REGSTR
STOP
previously registered students
ROUTER
students ready for testing
masters
CATSTR
non-masters or "quit"
STOP

Figure 2

PROGRAM COMPONENTS OF THE CMI SOFTWARE

student has met the prerequisites. If the student has met the prerequisites for only one module, the appropriate pretest or posttest for that module is generated. If a student has met the prerequisites for more than one module, he or she is given the choice of the module to be tested. In this way, the system assures that students go through the course in the manner in which it was intended. This constraint strengthens the instructional design of the course by guaranteeing that each student possesses all of the prerequisite knowledge required for each module that he or she is going to study. The system does not allow a student to take a test on a module for which he or she has not mastered all of the prerequisite modules.

The Router Program also gives students the option of displaying their statuses on each of the modules in the course. These statuses are reported as:

- Not attempted
- Pretest tried but not completed satisfactorily
- Pretest completed satisfactorily; posttest skipped
- Posttest tried but not completed satisfactorily
- Posttest completed satisfactorily

Students are allowed to take a pretest for a module only once. All subsequent tests are automatically interpreted as posttests, because it is assumed that if a student does not pass a pretest he or she will go and study the corresponding module. Students are allowed to take posttests as many times as necessary to complete them satisfactorily, i.e., demonstrate mastery on all of the objectives in that module. (Tests are generated interactively in real time, so no two tests are exactly alike. See the discussion below.)

The Testing Program

The Computer-Assisted Test Administration Program (CATSTR) generates both pretests and posttests. These tests are administered to students at a computer terminal. The purpose of the ComputerAssisted Test Administration Program is to classify the student as either a master or a non-master on the specific module being tested, and to make this classification in a minimum amount of time. To accomplish this, the Test Admin-

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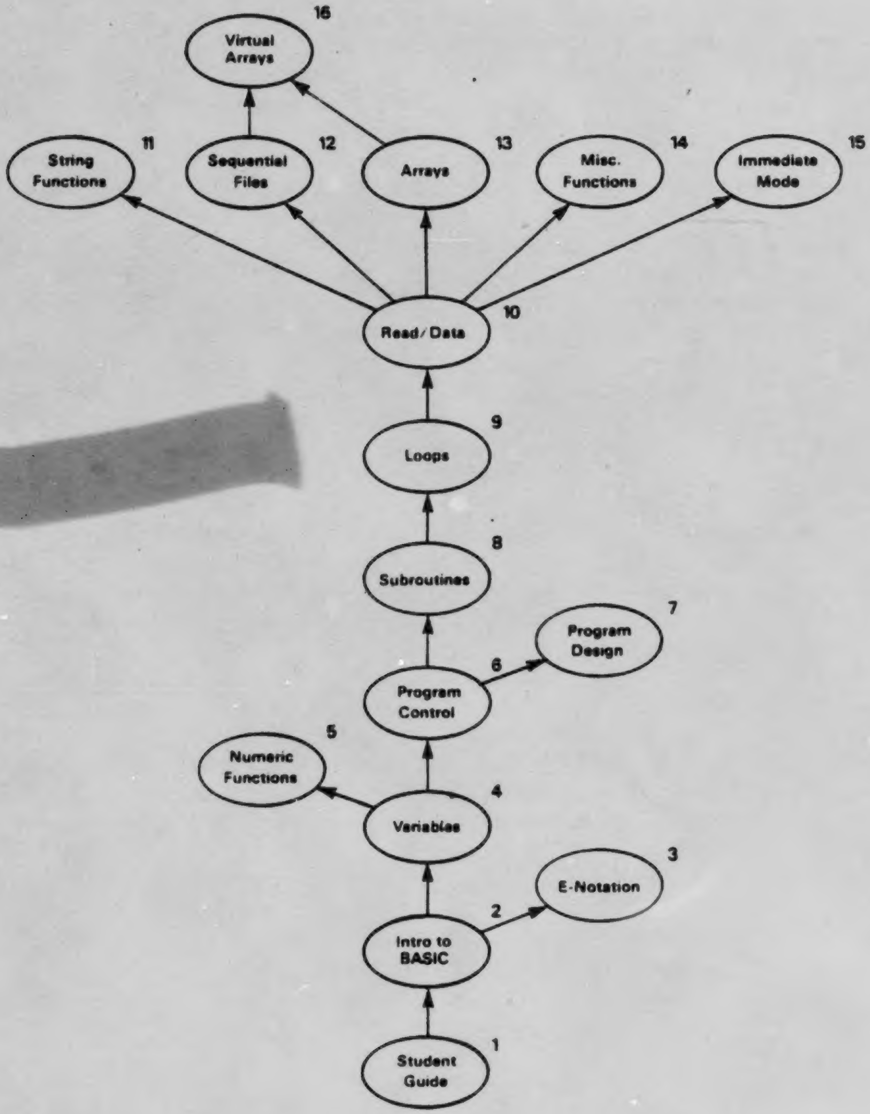
16
Virtual Arrays
String Functions
11
Sequential Files
12
Arrays
13
Misc. Functions
14
Immediate Mode
15
Read/Data
10
Loops
9
Subroutines
8
Program Design
7
Program Control
6
Numeric Functions
5
Variables
4
E-Notation
3
Intro to BASIC
2
Student Guide
1

Figure 3

PREREQUISITE RELATIONSHIPS BETWEEN MODULES
IN THE BASIC PRIMER

istration Program evaluates each student response with a sequential probability test ratio. This algorithm is discussed briefly below, but has been described elsewhere in detail (Heines, 1978a and 1978b).

The algorithm evaluates a student's score after each item is presented. This evaluation is used to classify the student in one of three categories. If the student's score exceeds a mastery threshold with a predefined level of confidence, the student is classified as a master and testing is terminated. If the student's score is less than a non-mastery threshold with a specified degree of confidence, the student is classified as a non-master. If the student's score falls within these two thresholds, another item is presented. Once the student responds to this item, the evaluation algorithm is repeated.

Using the sequential probability test ratio, it is possible for a student to remain forever in the "uncertainty band" between the mastery and non-mastery thresholds. For this reason, testing is terminated after 30 items have been presented regardless of the student's score. At this point, the student is classified as either a master or a non-master by determining the threshold that his or her current score is closest to.

Thirty is a rather large number of items for each module. To make the tests truly repeatable, more than 30 items are needed in the item bank for each module so that the randomized selection process does not produce identical tests. For The BASIC Primer, there are 754 items in the entire bank. This allows an average of about 45 items for each module. Since it is expected that very few tests will actually be 30 items long, this average is sufficient to yield a very large number of different test forms.

Students who demonstrate mastery on a test are branched back to the Router Program. They then select the next module on which they would like to be tested. Students who do not demonstrate mastery on a test are told the objectives on which they missed items. The CMI system then halts, and students are directed to do additional study off-line.

Students who have completed all of the modules in the course are branched to the Feedback Program. This program asks for student comments on the course and generates another data listing file. This listing file verifies that the student has earned a diploma and contains other data that is needed by the course development group to evaluate the training package. Students are directed to mail this file back to the course development group either on a machine-readable media, or they are asked to print this file on paper and mail it. In either case, this data is combined with data from other students in other training locations by a large system within the course development group. It is this feedback data that is used to evaluate the training package as a whole.

EVALUATION QUESTIONS AND STRATEGIES

The data described in the preceding section will be used to try to answer five research questions on the system. Each of these questions and the strategy that will be used to evaluate the data is described in the paragraphs that follow.

(1) What percentage of customers who study the training materials will use the CMI system?

There are two ways in which we will know how many students are using The BASIC Primer. First, we will have data on the number of CMI systems in use from our corporate sales data. Second, we will have some idea of the number of students taking the course by the registration forms that are generated by the New Registration Program. These two pieces of data, taken together, should give us a good idea of the number of people who at least began using the system.

After any student has completed the first ten modules of the course, a new listing file will be generated for that student. This file will contain the status data on all of the students who are registered on that system. From this data we will be able to ascertain how many students began the course but did not complete it. That is, we should be able to know how many students began using the testing system and did not continue. If we find that a large number of students fall into this category, it will be necessary for us to investigate further the reasons that they discontinued the use of the CMI system. Most importantly, we would like to know whether they continued studying the modules but just gave up studying the tests. If this is the case, it will be clear that the CMI system did not fulfill its goal. On the other hand, if we find that most students did continue to use the CMI system, the status data generated at this point will give us an excellent picture of how the system and mastery algorithm are working.

(2) Will those students who use the CMI system use the tests as intended?

In addition to updating the status records for a particular student each time that he or she takes the test, the system will maintain a test history file. This file will record data on each test that is administered in chronological order. Each test history record will record

- the student number,
- the module being tested,
- whether the test being administered is a pretest or a posttest,
- whether the test being administered is a normal test or a special 30 item test (used for reliability measurements; see below), and
- the date and time that the test was started.

This data will allow us to ascertain whether a student is just retaking tests one right after the other or actually studying between test administrations. We will assume that if a student repeats a test in less than ten minutes, that he or she did not return to the materials before requesting a retest. On the other hand, if we find that the time between repeated tests is on the order of 15 to 30 minutes, we will assume that the student did look over the material and possibly do additional exercises before he or she returned to the system for a retest.

The test history file will also tell us the order in which students go through the course modules. It will provide a trail which we can analyze to assure that the Router Program did not allow students to go on to more advanced modules before they met the prerequisites.

(3) Does the sequential probability test ratio reduce test lengths significantly?

Each module on the system has an associated log file. One of the types of data that is stored in this log file is the length of each of the tests that is taken. These lengths are recorded in four categories. They are recorded for masters on pretests, non-masters on pretests, masters on posttests, and non-masters on posttests. If the sequential probability test ratio works properly, we should find that the lengths of non-master tests are significantly less than the lengths of master tests. In addition, we should find that pretests on which mastery decisions were made are, on the average, longer than posttests on which mastery decisions are made. This result should occur because the criteria for mastery on pretests are more stringent than the mastery criteria on posttests. In addition, we hope to find that the average length of a test is considerably shorter than 30 items. This will indicate that the sequential probability test ratio was useful in reducing test lengths.

Two additional items that are stored for each student will help us ascertain whether any reduction in test length due to the sequential probability test ratio is significant. These items are the total amount of time that each student spent testing, and the total number of test items that were presented to that student. By dividing the total time by the total number of items, we will have an indicator of the average amount of time that it takes for a student to respond to a single test item. By looking at the number of tests that the student has taken and the amount of time that would have been required if these had been fixed length tests of say 20 or 30 items, we will have an indicator of the amount of time saved by using the sequential probability test ratio. Again, the decision algorithm will prove itself useful if the amount of time saved is a significant portion of the total amount of time spent testing.

(4) Is test reliability maintained even when the sequential probability test ratio causes short tests to be administered?

To obtain a measure of the tests' reliability, every fifth test that is administered to a student will be forced to 30 items long regardless of the results of the sequential probability test ratio. When this occurs, the system will record two decisions for the student. It will first record the decision that it would have made if testing had been terminated as soon as possible by applying the sequential probability test ratio. It will then continue the test and record the decision that is made after 30 items have been presented. These two decisions will be compared in a 2 x 2 contingency table. The analysis of this contingency table will be made by applying the G index. This index is a refinement by Livingston (1976) of the percentage of agreement first described by Carver (1970).

Using the contingency table in Figure 4, Carver defined the percentage of agreement as:

$$P0 = \frac{a+d}{a+b+c+d}$$

This measurement varies between 0 and 1.

Swaminathan et al. (1974) agreed with Carver's concept of criterion-referenced reliability as a coefficient of classification, but preferred a more sophisticated computation known as the kappa

		CLASSIFICATION ON T1	
		Master	Non-Master
CLASSIFICATION ON T2	Master	a	c
	Non-Master	b	d

Figure 4

FREQUENCIES OF AGREEMENT BETWEEN MASTERY AND NON-MASTERY CLASSIFICATIONS ON TWO SETS OF TEST DATA

coefficient. Swezey and Pearlstein (1975) preferred an even more sophisticated approach known as the *phi* coefficient. Livingston's coefficient, the G index, is simply:

$$G = 2 \times (P0 - 0.5)$$

This coefficient varies between -1 and +1, and is therefore compatible with the *kappa* and *phi* coefficients. (A more detailed discussion of this mathematics is provided in Heines, 1974b.)

(5) Are all of the test items on the system working properly?

In addition to the test length data, the log file for each module also records item analysis data. This data is a tally of the number of times of that each response was chosen for each question presented. Like the test length data, the item analysis data is separated into four catagories. That is, tallies are kept separately for

- pretests on which mastery decisions are made,
- pretests on which non-mastery decisions were made,
- posttests on which mastery decisions were made, and
- posttests on which non-mastery decisions were made.

This allows us to compute pretest/posttest and master/non-master discrimination indices. Therefore, we will be able to ascertain how well each item discriminates between masters and non-masters as well as how well it discriminates between pretests and posttests. The log data from various training sites will be combined to give us a large data sample. This should make the item analysis very significant.

GLOBAL ISSUES

The BASIC Primer is the first computer-based course being offered by Digital Equipment Corporation. We feel that the use of the computer in our current mode gives us the power to evaluate our training materials objectively. Never before have we been able to collect this type of data on a training course. If the CMI system fulfills its goals, it will not only improve the quality control of our courses, but it will provide us with a vehicle for improving all of the courses that we offer in this mode. The BASIC Primer and its complementary CMI system are currently being tested in selected sites in New England. The final version of this training package should be available to customers in the spring of 1979.

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An Analysis of Instructional Delivery Systems in Vocational Education Comparing Computer-Managed Instruction, Teacher-Delivered Module (Paper), and Lecture-Demonstration for the Same Instructional Module.

Needs of Problem Area. This study developed from a concern of how individualized instruction in vocational education was delivered in an individualized program curricula. The initial idea was researched at the University of Delaware and found no examples of computer-managed instruction in vocational education that prescribed, delivered, and recorded results of individualized instructional modules of instruction.

During the past two decades the usefulness of the computer in science and education has been demonstrated by the rapid growth of applications. Vocational educators have devoted much of their time and effort in developing individual instructional systems which attempt to instruct students. Few vocational educators have progressed as far or as fast as the current technology in our society. Not many of the instructional systems developed have utilized a computer to assist vocational educators in individualizing instruction as professed by Frantz (1974).

Vocational education has no information concerning the use of the computer to manage an individualized instructional system which would prescribe, deliver, evaluate, and record student results for the instructor. This might be another technique to develop and deliver competencies needed by vocational students. The development and future use of individualized instructional systems and computer-managed techniques is inevitable, and this trend will continue with the educational technology within our society. The findings from this study should assist in the need for development of instructional programs useful to both vocational educators and students.

Purpose. The purpose of this study was to examine the instructional strategies which are most effective for a group of students. Characteristics, such as reading and grade levels are compared in terms of student achievement of a criterion stated objective delivered by three different instructional techniques. Data was gathered about selected instructional delivery techniques; namely, teacher-lecture, teacher-module (paper), and computer-managed instructional delivery.

Specific Objective. The major student objective was: using three instructional delivery techniques, which will best assist students at varied reading and grade levels to achieve a stated criterion referenced terminal performance objective?

Methodology. Through the University of Delaware, Department of Occupational Education, in September 1976 a computer-managed instructional delivery and management record program was developed. Next, a module of instruction was developed that could be delivered via the CMI system. After field testing the module, a vocational population was identified to test the delivery of the module and test the CMI system instructional technique with other identified instructional techniques.

Instrumentation. Three instructional techniques (treatments) were delivered to the three grade levels and four reading levels grouped across each instructional technique. CMI programs and the module (instrument) have been developed for this study with the assistance of members of the Department of Occupational Education at the University of Delaware and with the assistance of the Graduate Office of Education at the University. This is the College of Education's authority on all aspects of research development and dissemination at the University of Delaware.

The instrument developed and used in this study was a module of instruction on reading micrometer measurements. This competency was selected because each instructor included a reading micrometer measurement competency in their curriculum.

The module of instruction for reading micrometer measurements was then piloted for this study. The module was delivered via the computer-managed and teacher-module (paper) instructional techniques to vocational graduate students in Occupational Education at the University of Delaware. Their comments and revisions were used in developing the final instrument used at Delcastle Technical High School.

Data Source and Sampling Design. The sample population consisted of 202 students in related drafting classes at Delcastle Technical High School in Newport, Delaware. Content for each instructional module was limited to instruction on reading micrometer measurements using three instructional delivery techniques that would be implemented and data gathered for this study. The study was limited to:

1. Three instructional delivery techniques having the same content.

2. The student achievement [illegible] the stated terminal performance objective was limited to the extent that the instrument used to measure student achievement is valid.

3. The student reading levels were limited to the extent that the California Test of Basic Skills (CTBS) measures what it is purported to measure.

Every student on each class list was selected for one of the three instructional techniques. The first student was selected randomly and two students thereafter received the second and third instructional techniques respectively. The same procedure was used until all students had been selected.

For purposes of this study design, each student was grouped by:

1. Their reading level into one of four national percentile groups.

2. Their reading percentile group by grade level.

3. Randomly systematically selected from their grade level and reading percentile group to receive one of the instructional techniques.

A three-by-four factoral design was used to show what student, at what reading percentile and grade level, receiving which instructional technique (treatment), achieved the criterion stated objectives. This provided data to examine its relationship to the study's hypothesis. Each of the three grade levels had this type of factoral design.

Findings and Conclusions. The findings of this study support evidence indicating that student achievement was highest with those students who received the computer-managed instruction. However, the evidence and related literature available for student achievement and instructional delivery techniques that include CMI as designed in this study are not readily available. The analysis of results among the three grade levles, four reading levels, and student achievement indicated the relationship of the teacher-lecture instructional delivery and student achievement was not significant. Achievement scores for those who had the teacher-module and achievement was highest with students who received the CMI module of instruction for all reading and grade levels. This study developed and implemented computer-managed instructional delivery that could be used to deliver most types of developed individualized instruction and adapting computer resources to existing curricula in the vocational education classroom. Implementing this type of computer-managed delivery is not that difficult, and the ability to adapt most curricula material to this format can be completed in a minimum amount of time. The real reward is when editing and updates are needed to the curriculum information, it becomes very easy and quick for the instructor and provides students with up-to-date, pertinent materials.

There is evidence to support that other areas of research using CMI, such as reading level and the ability of students, IQ, student achievement, student selected scheduled individualized instruction, are just a few in which the effectiveness and potential of CMI systems in vocational education could be researched.

Educational Implications. The results of this study indicate that a viable computer-managed delivery system for individualizing instruction for vocational education can be developed and implemented successfully. Although the use of the computer-managed system in this study was limited to a relatively small number of students, it does serve as a model for other vocational curriculum developers and administrators to emulate in providing career exploration experiences, job entry competencies, and other competency oriented individualized instruction for students at the secondary school level and perhaps beyond. This study demonstrated that it was feasible to develop a computer-managed instruction system that could individualize instruction for students and provide record-keeping services to instructors and students enrolled in a variety of different vocational areas.

Computer-managed instructional (CMI) delivery has much potential for the future. Research needs to be conducted on the effect CMI will have on training students in higher education, the levels that CMI are most effective and feasible, the relationships to personal, facilities and other elements of education and industry. These can become the rationale for much future research in this area of curriculum delivery and delivery of individualized instruction.

The potential of CMI systems at all levels and in many areas appears to have a promising future and advantages for students, teachers, and administrators. Its growth is evident with the technology and current development of the computer technology and curriculum needs. This author plans to continue research with CMI systems at all levels and examine the future directions and possibilities of the computer and its role in the management and delivery of educational curricula and information.

A Generative Computer System to Teach Language to the Deaf

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Introduction

Deafness is primarily a communication handicap. Because of drastically reduced language input both in infancy and early childhood, those born deaf are typically severely delayed and limited in the acquisition of English. This English language deficit in turn becomes the primary factor preventing adequate development of reading skills. This problem is so severe that a majority of 18 year old deaf students do not read as well as the average 4th grade hearing child [DiFrancesca, Wrightstone].

This paper describes a recently begun project which has as its goal the development of a generative computer system to aid deaf students in both the production and comprehension of written English sentences. The focus of the system is not on what to teach but rather on how to learn. For this reason, it is designed to be a resource which is in large part under student control. Thus, within certain limitations, the learner decides the content and basic features of each interactive tutorial session.

Overview

The design of the tutorial system involves two essential system capabilities: the capacity to generate an effectively infinite number of simple to complex English sentences which demonstrate correct language use, and tutorial dialogues which are carefully designed to draw upon this generative capacity. In addition, this system will be aware of common "deaf strategies" and will be capable of guiding the student toward appropriate language use. At all stages of development, the system is designed to meet the special language needs of the deaf student.

In reviewing the recent history of computer-based education, it has become clear that the technology-push by the developers of educational innovations must be replaced by the demand-pull of the ultimate users of this new technology. Consequently, the ILIAD (Interactive Language Instructional Assistance for the Deaf) system is being designed with reference to the following important criteria of educators who would use this technology: convenience, low cost, instructional effectiveness, and diagnostic capability.

By using powerful language generation and diagnostic capabilities, this language tutorial system represents a significant advance in "intelligent" computer-based instruction. All of these features will be built into a desk top micro-computer and TV terminal capable of generating millions of sentences and using them in a broad range of instructional dialogues.

The Current System

Although the ILIAD project has only recently begun, we already have a working, though very preliminary and limited, version of the system. The annotated dialog below (annotations in curly brackets) illustrates its capabilities.

The interface which this version of the system presents to the user is far too sophisticated to present to a student as it uses rather high level syntactic constructs and technical vocabulary. We are geared to the student's reading level and which will allow options to be chosen by example rather than by name. This exerpt is meant to acquaint the reader with the flavor of the dialog and the system's capabilities. The user's answers are preceded by "->" or "answer:". Following the example given below, the general system organization will be explained and each component of the system will be described in detail.

```
      Welcome to the first version of ILIAD


To sign on enter your first name
-> Lyn                  {The user signs on ...}


     Hi Lyn!


What kinds of sentences do you want?
 ---- If you want some help type -> HELP
-> HELP                  {... and asks for help}


 Choose from the following list:
      YES-NO            {Some of the sentence characteristics
      TAG               affect the base component, some affect
      NEGATIVE          the transformational component, some both;
      PASSIVE           the user does not have to be aware which
      VERB              part of the system s/he is controlling.}
      DIR-OBJ
      IND-OBJ
      TENSE
      PROGRESSIVE
      PERFECT
      MODAL
 If you wish to negate one of these options previously
 selected   type -> NO
            Then type the option.
 If you wish further information about a particular kind of
 option     type -> DESCRIBE
            Then type the option.

-> DESCRIBE PROGRESSIVE   {A request for further clarification.}

            This will produce -ing sentences.
      e.g.  The man is running.

-> DESCRIBE MODAL

            This allows you to specify a modal for the
            sentence. Choose from CAN, MAY, MUST, or SHALL.
      e.g.  -> MODAL CAN  might produce
            John can see the dog.
```

```
-> YES-NO     {The user selects a set of specifications.}
-> NEGATIVE
-> DIR-OBJ
-> DONE     {The specifications are finished.}


 What kind of test would you like?
-> TRUE/FALSE     {Other choices such as MULTIPLE/CHOICE
                  have not been implemented yet.}

 How many sentences would you like to see?
 -> 4

 Doesn't like the girl the cats?  {A incorrect sentence.}
answer: YES                       {An incorrect answer.}
?????????????????????????         {Error indication.}
 Doesn't like the girl the cats?  {Problem re-presented.}
 answer: NO                       {Correct answer given.}
It should have been:   Doesn't the girl like the cats?

 Don't the girls see the car?  {A correct example.}
answer: YES
!!!!!!!!! VERY GOOD !!!!!!!!

 Doesn't the cookie see the man?  {Grammatically correct, but
answer: NO                        meaningless, so it is wrong.}
 Doesn't the man see the cookie?  {The correct version.}
!!!!!!!!! VERY GOOD !!!!!!!!

 Doesn't the girl the cookie like?  {Verb and object switched.}
answer: NO
 Doesn't the girl like the cookie?
!!!!!!!!! VERY GOOD !!!!!!!!


 What would you like to do now?
-> HELP   {Help is always available.}


Choose from the following:
      LESSON        {Generate more examples.}
      RESTART       {Get new specifications, tutorial, length}
      SEE-SCORES    {Print out statistics.}
      ZERO-SCORES   {Reinitialize statistics.}
      SENTENCE-OPTIONS {Specify additional options.}
      CHANGE-LESSON {Choose a different tutorial.}
      CHANGE-LENGTH {A different number of examples.}
      QUIT          {Finished with the session.}
 If you would like more information about one of these
 options  type -> DESCRIBE
          Then type the option


 What would you like to do now?
-> SENTENCE-OPTIONS  {The student elects new specifications.}


What kinds of sentences would you like?
 ---- If you want some help type -> HELP

-> IND-OBJ      {These specifications are added to
-> MODAL CAN    the previous set.}
-> TENSE PAST
-> DONE


 What would you like to do now?
-> LESSON

 Couldn't give the woman the book the boy?
answer: NO
 Couldn't the boy give the woman the book?
!!!!!!!!! VERY GOOD !!!!!!!!

 Couldn't the women give the women the cookie?
answer: YES
!!!!!!!!! VERY GOOD !!!!!!!!

 Couldn't the girl the boys give the spoons?
answer: YES
?????????????????????????
 Couldn't the girl the boys give the spoons?
answer: NO
It should have been:
        Couldn't the girl give the boys the spoons?


 What would you like to do now?
-> QUIT

     Bye Lyn
```

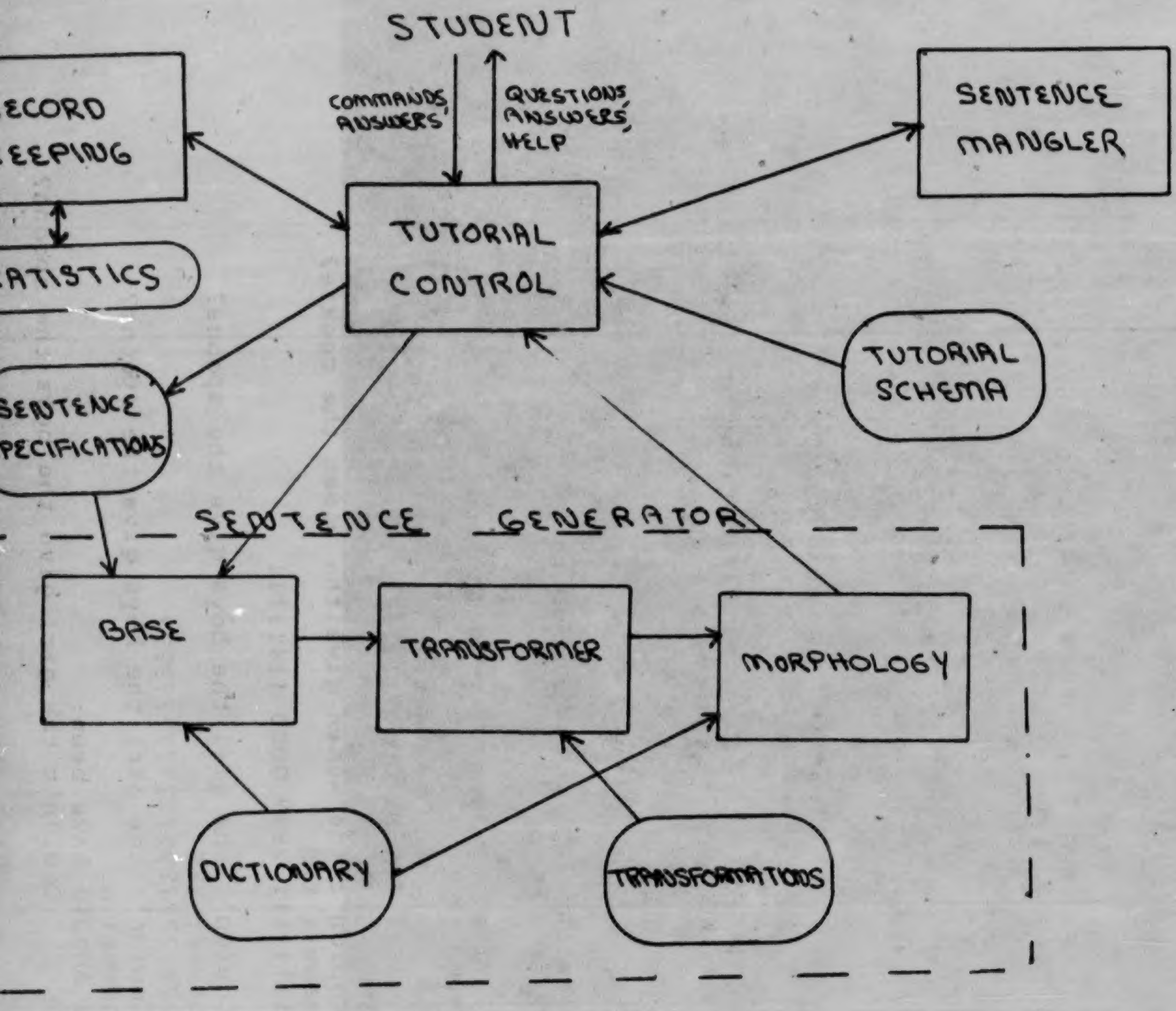

STUDENT
COMMANDS, ANSWERS
QUESTIONS, ANSWERS, HELP
ECORD EEPING
ATISTICS
TUTORIAL CONTROL
SENTENCE MANGLER
TUTORIAL SCHEMA
SENTENCE PECIFICATIONS
SENTENCE GENERATOR
BASE
TRANSFORMER
MORPHOLOGY
DICTIONARY
TRANSFORMATIONS

Figure 1. The ILIAD System

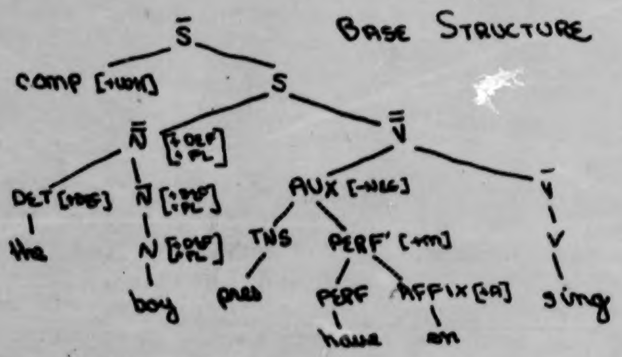
The system which generates the dialog is shown schematically in Figure 1. The main tutorial controller collects commands and answers from the user and calls upon the sentence generator, the record keeper, or the sentence mangler as necessary to produce a question, answer, or helpful message for the user. The record keeper is, at present, a straightforward recorder of the number of questions of each type which are answered correctly.

The Generator

The theoretical model underlying the sentence generation process is that of transformational grammar. While other linguistic models are available, there are a number of reasons for choosing to base the generator on this method. It is designed to be a generative model of English, it is more well known to English teachers than other linguistic formalisms, and it is easy to explain to those who are not familiar with it, in part because very little special terminology need be used. It allows clear separation and identification of parts of the process of generation a sentence, thus it is amenable to the imposition of a priori constraints to produce or avoid certain grammatical constructions. Finally, it can be incrementally modified to produce sentences with structures which are not correct in standard English but which are commonly produced by deaf students.

This model is embodied in a three part program to generate sentences. The base component, which is controlled by the directions of the tutorial component, uses a dictionary to produce a "deep structure" tree, an example of which is shown at the top of Figure 2. When alternatives are not constrained by the tutor, random choice is used to select appropriate structures and words. Semantic feature checks are made to ensure that the final sentence will be meaningful as well as grammatical.

Once the deep structure is constructed, it is given to the transformational component which cycles through the system's set of transformational rules, using the a priori constraints to avoid trying transformations which should not apply and to force the application of transformations which would otherwise be


BASE STRUCTURE
S̄
COMP [+WH]
S
N̿ [+DEF] [+PL]
V̿
DET [+DEF]
N̄ [+DEF] [+PL]
AUX [-NEG]
V̄
the
N [+DEF] [+PL]
TNS
PERF' [+m]
V
boy
pres
PERF
AFFIX [+n]
sing
have
en

SUBJECT - AUX - INVERSION TRANSFORMATION:

PATTERN: (S̄ COMP [+WH] (S N̿ TNS NODE [+m]))
1 2 3 4 5 6

CHANGES: (LCHOMSKY 2 6)
(LCHOMSKY 2 5)

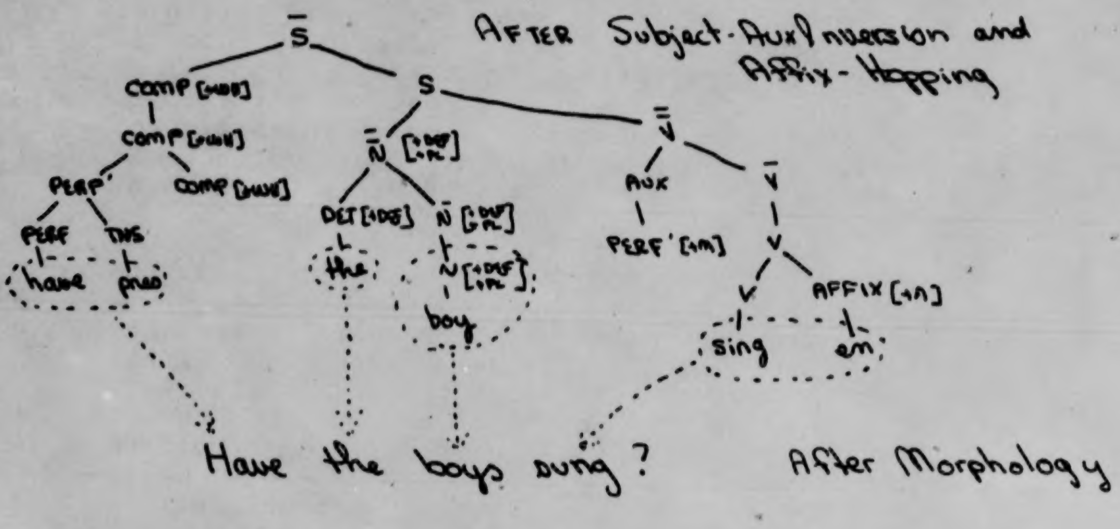

AFTER Subject-Aux Inversion and Affix-Hopping
S̄
COMP [+WH]
S
COMP [+WH]
N̿ [+DEF] [+PL]
V̿
PERF'
COMP [+WH]
DET [+DEF]
N̄ [+DEF] [+PL]
AUX
V̄
PERF
TNS
have
pres
the
N [+DEF] [+PL]
boy
PERF' [+m]
V
V
AFFIX [+n]
sing
en
Have the boys sung?
After Morphology

Figure 2. Stages of Sentence Generation

optional. Each transformational rule consists of a pattern which the tree must fit if the rule is to be applied, and a set of changes (additions, deletions, permutations) to be made to parts of the tree. A sample transformation is also given in Figure 2.

The transformational component eventually produces a "surface structure" tree which embodies the final syntactic structure of the sentence (see Figure 2.). The final, morphological, component uses this structure together with information from the dictionary to inflect the lexical items in the tree as needed and to produce a sentence ready to be shown to the student.

The Sentence Mangler

In some tutorials such as the one requiring judgement of the correctness of a sentence, it is necessary for the tutor to produce an ungrammatical sentence. While it would be easy to randomly permute the words of a grammatical sentence, the result would likely resemble "word salad". An additional problem with this approach is that it might occasionally result in another grammatical sentence (e.g. "Didn't the boys see the girl?" is a permutation of "Didn't the girl see the boys?"). In neither case is the student benefited by seeing such a sentence, since the cases most confusing to students are those which are generated by specific non-English rules used by deaf students rather than a simple random ordering of words.

The sentence mangler is the component that is used in conjunction with the generator to produce non-grammatical English sentences which in many cases typify those produced by deaf students. It is used to produce a variety of rule-based structures, and although it is conceptually separate from the generator and tutor it actually blends with them in the implementation. Many of the incorrect strategies employed by deaf people in the production of sentences can be expressed as additional transformational rules; there are seven such rules in the system now. Other types of errors will be introduced by relaxing the conditions on some transformations, failing to apply a transformation which should apply, violating morphological rules (e.g. willn't for won't), and incorporating specific operations which characterize deaf students' production and comprehension.

The Future

The ILIAD project will continue to expand in a number of directions. In some areas this process is expected to be straightforward, for example dictionary expansion. As the lexicon is enlarged, each word will be assigned a vocabulary level as well as syntactic, semantic, and morphological features. The set of transformations will continue to be enlarged to generate modifiers and embedded clauses (relatives, complements, etc.). New tutorials including sentence production, comprehension, and imitiation will be introduced; these aspects of language use will be introduced through additional dialogue formats including multiple choice answers and recognition tasks. As mentioned above, the system will ultimately present instructions and help in terms which are easily understood by deaf students. Instructional materials to present the system to students and teachers must also be developed, and because there is a wide spectrum of information which a teacher may find useful in assessing a student's performance, both the keeping of records and their presentation to or interrogation by teachers must be explored.

In addition to these facets of the system which are already begun and must be expanded, there are a number of areas which we would like to explore and which are more complex than those given above. One area for further development regards the representation of conceptual structures to allow for teaching discourse processing skills such as generation of inference and presupposition. An additional function to be incorporated is a sentence parser which will have a variety of applications in the final ILIAD implementation.

In order to maintain inter-sentential coherency for embedded clauses or discourse, the system must have a knowledge representation which will allow combinations such as "Mary brought the book and ate lunch" but not "John died and drove the car." As reading level increases, it is necessary for the reader to draw conclusions and make assumptions about what is explicitly stated. (For example, the sentence "Mary fixed the car" invites one to infer that the car was broken.) Knowing what sorts of inferences are allowable and when to make them is an important skill which can be exercised with some of the same kinds of tutorial mechanisms as syntactic skills. Finally, because students should be encouraged to produce sentences of their own, those sentences should be processed by a system aware not only of the correct answer but also of common deaf strategies so that even more insight could be gained into the student's problem areas. Techniques do exist in computational linguistics which could be used to approach this problem.

The goal of the ILIAD project is to develop a micro-computer-based system with powerful language generatin and parsing capacities. Development of this system, however, must be framed within the context of what we know about the process of language acquisition in general and language learning in deaf children in particular. In contrast to other bodies of knowledge which can be taught or enhanced through computer-based instruction, language learning involves a complex interaction of several learning processes. First, the learner must be exposed to language data which illustrates the important aspects of language structure. Second, the learner must generate hypotheses about what the underlying structure of sentences may be. And third, the learner must have an opportunity to test his/her hypotheses in a variety of contexts. By giving the student full control over the characteristics of the ILIAD language tutorial, deaf students will be able to ask for specific language "data" to be generated, formulate hypotheses, and test their ideas in a manner similar to the normal language learning process. By serving as a rich and flexible source of information about English structure, the ILIAD system will offer an important supplement to language acquisition in deaf children.

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A Computer-Based Writing Laboratory for Deaf Students

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The meaning of writing

Recording ideas, thoughts and images is a fundamental need and highly valued skill. Some activities so totally depend on writing that they are all but impossible without it. The intrisically motivating aspect of writing is visible in young children's scribblings.(1) The fact that these scribblings are not an empty imitation of adults is often immediately apparent from the child's spontaneous speech accompanying the "writing." Their drawings, too, are obviously motivated not only by the fun of the activity, but also by a desire to represent what they know.

Besides its expressive function, writing also provides a kind of feedback to the child, helping to develop his expressive skills. Some aspects of language development may not take place at all without writing. Irene Athey(2) emphasized the importance of language play in the education of deaf children. Such play is richer when one has both the ephemeral (spoken or signed) expressions and the lasting (written or taped) compositions to play with. Writing affords the means to compose and revise thoughts. It is a medium for exploring relationships and alternate means of expression.

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(1) Graves, D., 1977. Balance the basics: Let children write. Paper presented to Ford Foundation, 1977.

(2) Athey, I., (in press). Language, Reading and the Deaf. In H. Reynolds, (ed.), Gallaudet College Conference on Reading in Relation to Deafness. Washington, D.C.: Gallaudet College Press, (in preparation). Paper first presented May 25, 1978.

For the deaf person, written English has additional significance.

->Writing allows self expression in English without time pressure, a relief to any non-native language user.

->It facilitates communications with the hearing population for social, educational and business purposes.

->It is the primary source of current information for a person who cannot use the radio or telephone.

Most prelingually deaf people are seriously deficient in reading and writing English. Their lack of knowledge of English is due in part to the relatively limited contact with spoken English that is possible for the young deaf child. However, the typical schooling of deaf children seriously compounds their problem of learning English by perpetuating the abnormality of their experience with written English.

Hearing children acquire English naturally and grow up with the experience of using their language to control others long before they encounter school lessons. By contrast, the prelingually deaf child typically gets most or all of his English (and frequently his first systematic sign language) in school, where the predominant role of language (for both hearing and deaf children) is responding rather than initiating or controlling. Although his English is developed as a tool, it is not really his to use. Rather, it is a means for others to control him. Unless English is of service to the child, his spontaneous use of it will be minimal. There is good reason to believe that language simply cannot develop in the absence of communicative purpose.

Brennan feels that the deaf child's difficulties with English arise from not getting enough experience with the language-in-use to apply his presumably normal linguistic capabilities to the learning of this language. She states:

> Attempts to interfere with the normal acquisition process in hearing children by direct teaching have proved notoriously unsuccessful: we cannot, it seems, usurp the child's own role in language development. Unfortunately, this is precisely what has been attempted in the case of the deaf child.... Access to meaningful language in use must be regarded as a pre-condition of normal language development.... Rather than simply concentrating on ways of making meaningful language available, educators have attempted to artificially shape the linguistic data they...present to the child so that he can, supposedly, more easily learn. There is some evidence to suggest that by denying the child the opportunity to construct his own language, we ensure that he will never fully master any language system, least of all the artificial package commonly presented to him as language.(1)

And Wilbur states:

> The study of language within a pragmatic framework includes contextual environments larger than the sentence, such as the paragraph or conversation.... The problem [of deaf English] most likely arises from the heavy emphasis that is placed on the proper structure of the single sentence in language training programs for the deaf.... As long as the modifications in syntax that arise from pragmatic context are ignored in language programs, deaf students' facility with English will continue to be stilted and stereotyped.(2)

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(1) M. Brennan, 1975. "Can deaf children acquire language?" American Annals of the Deaf, Vol. 120(5), p. 464

(2) R. B. Wilbur, 1977. "An explanation of deaf children's difficulty with certain syntactic structures of English." Volta Review, Vol. 79(2), p. 86

The message of these two scientists is especially important to us as educators of the deaf concerned with computer-based instructional systems.

- ->We must de-emphasize right-wrong, S-R, multiple-guess lessons and instead emphasize the communication component of writing.
- ->We must deal with units larger than phrases.
- ->We must take advantage of the natural tendency for people to play with their own language.

A beautiful balance between expression and mechanics can be seen in Graves' writing conference method(1) which treats writing as an ongoing process rather than a finished product. As a piece of writing evolves, one focusses first on clear expression of ideas and then on improving the form.

A computer-based communication experience

Traditional drill and practice has been limited in that it focusses mainly on the mechanics. We at BBN and UNH have been developing computer based instructional systems using writing as the means to communicate and interact with other people and with computer games, thus giving the written use of English its natural function.

In an experiment designed and conducted by Richard Rubinstein at BBN, a demonstration CAI system including a computer mail program was installed in a school for the deaf.(2) Students in their free time could go to a terminal and compose a letter to a friend or teacher and then send that letter through computer mail. When the other person logged on to the computer, the mail would be delivered through their terminal. It is important to note that:

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(1) op. cit.

(2) Portions of the following description of the project and its results are taken from R. Rubinstein & E. P. Goldenberg, 1978. "Using a Computer Message System for Promoting Reading and Writing in a School for the Deaf." 7th Annual Conference on Systems and Devices for the Disabled, Houston, Texas, June, 1978. E. P. Goldenberg & R. Rubinstein, (in preparation). "Electronic Mail: An Approach to Stimulating, Studying and Improving the Written English of Deaf Students."

- ->all participation in the mail system is voluntary (there are no assigned letters)
- ->letters are personal things sent between two individuals and unless the two individuals want to correct each other's work, no corrections are imposed from the outside
- ->letters are read only by the writer and the recipient. This last point may be particularly important for children whose entire experience with language, including the sign languages, is that privacy is rare.

Our experiences with this computer-managed message system have shown the system to be a very powerful intrinsic motivator for writing. Students, without suggestion or encouragement from teachers and without artificial "rewards" from the computer, have been sending volumes of mail to each other in the form of love letters, insults, funny notes, and invitations to play together. In addition, they have been leaving private messages for teachers, such as requests to sleep over at the teacher's house. This system solves much of the problem of providing a context of communication rather than exercise for the student's English.

Teachers and school staff also use the message system, sending messages to each other and to students as part of school activities and for personal communication. Thus, children see writing as a useful, adult activity, not merely an academic exercise. The fact that some children and staff spend part of their time at other schools, for example in a main-streaming program, makes this communication facility all the more valuable. Electronic mail makes it convenient to leave private messages for people, even when they are not present to receive them. It is thus possible to notify students about special events, meetings in school, TV programs that may be of interest to them, birthdays, and the like, or to poll them on their opinions about some issue of common concern.

For purposes of analysis, the BBN system kept copies of all messages sent or received by students. Great care has been taken to preserve privacy in this recording process and, for the protection of the interests of the children and staff at the school, all identifying information is eliminated from the record.

Here are several examples of messages sent by children at the school. The selection is reasonably representative, but there is too much variation to represent the full range in a few examples. In the letters which follow, the lines beginning with "To:" and "From:" are formatted by the computer, only the names being supplied by the child.

Letters 1-4 are from a 15 year old deaf girl.

Letter: 1 04-Nov-77 10:54 AM
To: {Girl 3} From: {Girl 10}
How are you? I am fine. {Girl 13} dont like you!
I will sleep over {Girl 13}s house .

Letter: 2 04-Nov-77 11:03 AM
To: {Boy 9} From: {Girl 10}
Why you broken new my necklace.
I dont like you broken new my necklace!

Letter: 3 05-Dec-77 12:17 PM
To: {Teacher 2} From: {Girl 10}
Dear {Teacher 2's last name},
Hi! How are you? I am fine. Do you think all right {Girl 19} and me will sleep over your house. I never visit you house. Do you like lots of animals? I love gerbils,dogs mices. That's all. Do you have any dogs or cats? I know your favorite animals!!! Do you like downstair? I don's like downstair. I like to upstair. I want you go upstair again!!! Your son {name} is cute!!! Your wife's name? I don't know your wife. I think your wife and son are nice!!
You are nice too!!!!!!! Where was you born? I was in {town}, Ma. I live in {town}. I know you live in {town} {Teacher 7} live there.

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Letter: 4          04-Jan-78 12:12 PM
To: {Girl 13}      From: {Girl 10}
HI {Girl 13},
    WHY YOU DON'T WANT GO TO SWIMMING. I LIKE TO GO TO
SWIMMING.
DO YOU LIKE {Girl 4}? DO YOU LIKE {Girl 3}   ?
I LIKE YOU MUCH!!!
DO YOU WANT TO SLEEP OVER MY HOUSE? I WANT TO SEE YOUR DOG.
I SAID "HI" YOUR MOTHER AND FAMILY. I LIKE TO YOUR FAMILY.
YOU ARE CRAZY!!!!!! HA HA HA HA HA HA HA HA HA
HA!!!!!!!!!!!!!!!!!!
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Letters 5 and 6 -- a correspondence between two 12-year-olds.

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Letter: 5         23-Nov-77 10:27 AM
To: {Boy 29}      From: {Girl 12}
 HI {Boy 29},
YOU ARE VERY CUTE.
YOU ARE VERY CRAZY.
   LOVE {Girl 12}
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Letter: 6          29-Nov-77 11:22 AM
To: {Girl 12}      From: {Boy 29}
Dear {Girl 12}
    You  are  beautiful!!!!
Why  cute  me  ?  Why  crazy  me  ?     Bowling
to  come  yes  or  no  ?  Do  you  want  to  go  and  get  ice
 cream  yes  or  no  ?  I  want  to  go  to  your  house.
                  love
                         {Boy 29}
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Letters 7 and 8 -- two social letters.

Letter: 7 05-Dec-77 08:59 AM
To: {Teacher 3} From: {Girl 3}

Hi ! I was happy to get your letter . I don't understand what succeeding mean . The answer your questoin are I want to goto The {name} high school. and yes, I like the teacher upstairs . I don't have a boyfriend. I think {Girl 32} want to write to you. I think she want to know your address . {Boy 26} said you are handsome . I think you are cute . Please write to me . love, {Girl 3}

Letter: 8 02-Dec-77 11:46 AM
To: {Girl 37} From: {Girl 8}

Dear {Girl 37}
You can come to my house for my birthday party.I want you to sleep over my house. My mother said ok. Maybe we can go bowling.
Love {Girl 8}

Several comments on this sample are in order. Perhaps the most important observation is that these letters exist at all. In a period of three months, over 600 letters were sent by a group of children who typically wrote little for assignments and almost nothing spontaneously. Many of the messages are quite long. Consider the letters 1-4 which were written over a two month period by a 15 year old deaf girl. Formal analysis isn't needed to observe the change, not only in volume, but in structure and style between letters 1 or 2 and letter 3 which was written a month later. Letter 4, written in a particularly silly mood and to a child, is evidence that the improvement seen in letter 3 is not due solely to the fact that it was addressed to a teacher. She writes more, asks questions that expect a response (rather than the formulaic "How are you?" of letter 1 and the rhetorical "Why you broken new my necklace" of letter 2) and "plays" with her English much more, using wild (and good) punctuation, and more casual and varied constructions. Not visible in these samples are the formatting games she played with her name, frequently typing it diagonally across the page at the end of her letters. Girl 29's statement "I don't understand what succeeding mean" (letter 7) and Boy 29's response to Girl 12 (letter 6) both show genuine concern for communication in addition to the vitality that is so obvious in all of the letters.

Composing on a computer

The writings shown above were composed without the any facilities for editing other than the ability to erase the last character or word typed on the current line. Once a carriage return was typed, completing a line, no further changes could be made to that line. Word processing systems that allow one to compose a letter, view it in its completed form, and then go back over it to improve it without retyping it completely have become commonplace in business settings and have vastly reduced the effort and personal cost in composing a satisfying document. Yet, these systems, which are entirely within the capabilities of many of the computers currently being used in schools, have not been used in this manner with children. Such an addition to the mail system, would allow students to alter their composition in any way, from minor typing corrections to full scale structural revisions, offering them an opportunity for another kind of privacy before exposing their writing to the possibly critical eyes of a reader. We have initiated such a project in a school system in New Hampshire. While it is too early to present any results, we have several expectations about how such a system might improve the quality of the student's experiences with written English.

Let us first set aside the special problems of the deaf student and consider how a computer editor influences anyone's production of a text.

A computer text-editor is not an active agent. It is an electronic scratchpad and makes no changes in the user's document that the user has not specifically directed it to make. What it _does_ provide is a convenient means for _manipulating the_ text that the user types in. Using an editor designed by one of the authors, moving an entire paragraph from one location to another can be accomplished with only five keystrokes.(1) Without the computer's ability to store and edit text, each change to a written or typed composition defaces it and requires that it be rewritten or retyped before handing it in. This puts a premium on catching all errors early and not making many changes after the first draft's corrections have been neatly typed into a second (generally final) draft. With the computer, each correction requires only the typing of the correction itself. This ease in correcting a document makes it highly worthwhile to search for further improvements, and provides the time within which to make those corrections.

By diminishing the penalty for typographical errors and assuring that changes are always easy to make, a computer text editor encourages faster typing, and cuts the time required for polishing a document. One can learn to ignore the imperfections of a first draft when the pain of converting it to a more satisfying draft is low. Faster typing and reduced worry about choice of words or order of presentation of ideas in the first draft can allow a writer to record his ideas more closely in step with the way he thinks, thereby allowing ideas to flow more naturally.

Ease in editing has advantages not only for social communication, but for teacher-student interaction as well. In particular, it allows the production of a written composition -- typically a one-way language effort -- to become interactive. Teachers can afford to expect a student to improve a piece of writing, rather than merely hoping that their comments and criticisms help the production of the next composition. This effectively allows both the student and teacher to avoid defining pieces of writing as "good" or "bad" and instead to think of them as "finished" or "unfinished."

The computer editor allows the child to engage in a kind of dialogue with himself as he looks at his written ideas, adds to them, embellishes them and takes pride in an attractively typed, personally designed as well as personally written creation. The child gains a kind of control of language that contrasts sharply with the response-to-teacher mode that is more common, and gains an opportunity to become active rather than passive in the business of refining his use of English.

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(1) Goldenberg, E. P., A Computer-Based Interactive English Language System for Deaf Students, BBN proposal P78-ISD-70.

For many deaf students, English has always been associated with pain and failure. Both the initial effort that must be expended and the amount of editing and correcting that a prelingually deaf person must go through are likely to be greater than that required of the average hearing person. That makes the efficiencies of the computer all the more valuable to the deaf writer.

The pragmatic context

The way in which a computer text editor supports our philosophy of education of the deaf (and our understanding of the recommendations of Brennan and Wilbur) should be clear. But editors, of course, are not enough. A computer-based writing laboratory must be a rich environment. Highly exciting interactive games which parse and respond to moderately complex written commands already exist(1) and can be augmented to respond intelligently to "deaf English" as well as standard English. Such a game which can understand a child regardless of defects in his English and can respond with standard English that the child can understand would provide another use for interactive written English in context. We feel that activities of this kind, activities which communicate with English rather than drill its forms, will ultimately be the most productive uses for the computer in developing language experiences for deaf children.

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(1) One such game is DUNGEON, created at the Programming Technology Division of the Massachusetts Institute of Technology Laboratory for Computer Science by Tim Anderston, Marc Blank, Bruce Daniels and Dave Lebling. It was inspired by the ADVENTURE game of Crowther and Woods, and by "Dungeons and Dragons" by Gygax and Arneson. This particular game makes use of a particularly unsophisticated parser compared with others developed by some of the aforementioned.

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ACCESS TO CAI FOR THE BLIND AND VISUALLY HANDICAPPED

Computer assisted instruction is growing rapidly. At present communication with CAI systems is typically through a computer terminal comprising a typewriter keyboard and a video display screen. While the keyboard presents no serious problems for the visually handicapped or even the blind, the video display screen cannot easily be used by them. As the use of computers grows in education, the visually handicapped will be increasingly cut off from important opportunities. This paper is to report on the development and testing of a general purpose computer terminal for use by the visually handicapped with the objective of given them the ability to communicate as effectively with computer systems as sighted students can.

Several prototype computer terminals have been developed at the University of Illinois which convert the computer output which would normally be displayed in small print on video screen into spoken English from a speech synthesizer and at the same time display each word separately in very large bright letters. Ongoing research involves the practical testing of a number of such terminals in an attempt to improve them so as to minimize the differences between the ease of communication with CAI and computer media by sighted persons and the visually impaired. Every effort is being made to use standard computer terminal hardware readily available from competing manufacturers, so that similar terminals can be immediately made and put into use by educational institutions throughout the English-speaking world.

1. OBJECTIVES

The objective of the research project is to improve, evaluate, and disseminate information about general purpose computer terminals for use by the visually handicapped, with the purpose of giving them easy access to CAI and other computer-based media used by sighted persons. Access to CAI is becoming increasingly important as the use of computers grow in education. Unless the visually handicapped can have such access they will be increasingly cut off from many courses and majors in educational institutions.

A number of techniques now exist for providing access for the visually handicapped to computers, but all existing techniques have serious drawbacks. Research at the University of Illinois has led to the development of prototype computer terminals capable of converting the regular output of any computer into synthesized English speech, while simultaneously displaying the individual words in large bright letters to aid the partially sighted. These terminals are being tested in a wide variety of education-related applications including data retrieval, computer assisted instruction, word processing, and scientific computation with the objects of both perfecting the terminals so as to minimize the gap between the ability of sighted persons and the visually handicapped to communicate with computers and also of simplifying the terminals and reducing their cost so that their wide-spread application will be possible.

Problems with Existing Approaches

The existing approaches to providing access to computers for the visually handicapped each have certain advantages, but all suffer from serious disadvantages. The following approaches will be examined in turn: use of human readers; optical character recognition; Braille; speech synthesis systems dependent upon special computer programs.

A human reader can give visually handicapped persons access to information displayed on a computer terminal. The advantages include the ability to selectively read or reread any portion of the display on request of the user, and the fact that the human will be able to intelligibly pronounce the words that appear on the terminal display screen. The major disadvantages of the human reader approach are the problems of availability, cost, and dependence. A human reader may be available only at certain hours on certain days; visually handicapped persons and their employers may have difficulty paying readers; the need to depend upon a reader may be psychologically damaging.

Computer terminals are commercially available which print output in Braille instead of displaying it upon a screen (13). Such terminals do allow visually handicapped persons access to many computer systems. They have the advantage of providing a portable permanent record of the computer output, and of avoiding dependency on human assistance. The disadvantages of Braille terminals are slowness and inaccessability to those who do not know Braille. Because the terminals typically run at much slower speeds than modern video terminals, they cannot be connected directly to many computer systems. In addition, the user wastes a great deal of time waiting for the computer output to be printed in Braille and then scanning the output by hand. Further loss of time may be incurred due to user fatigue, since many persons must rest their reading finger after a relatively short period of reading Braille. However the most significant disadvantage is that only a minority of visually handicapped persons can read Braille well.

The use of optical character recognition devices offers another way of giving visually handicapped persons access to computer terminal displays. Here there are two possibilities, the use of the Opticon device to convert the display to tactile data, or the use of the more advanced Kurzweil system to convert the display to synthesized speech (1,2).

The disadvantage of the Opticon device is slowness. The need to hand scan words greatly reduces reading speed, and this problem is complicated by the slow character recognition rate of even that minority of blind persons who have gone through the long training needed to be able to use the Opticon. The Kurzweil device avoids the problem of slow hand scanning. However for the next few years it will also be very expensive and in short supply. In addition, it elaborate optical character reading mechanisms add high costs unnecessary for computer use.

Systems have been developed which use special computer programs for conversion from English to speech synthesizer output, with the programs contained in the host computer, not the terminal (17). These systems greatly facilitate use by blind persons of those programs which have been specially converted for speech synthesis running on the particular computer. The main disadvantages of these systems is the lack of portability from computer to computer, and the limited access to programs even within the main computer. Unlike a standard terminal, which may be attached to any computer, these special programs require substantial modification for use on different computers. In addition, only a miniscule percentage of the very large numbers of existing programs have been modified to produce speech output, and labor costs for modification of any substantial percentage of them are prohibitive.

A New Approach -- the Talking Computer Terminal

Research at the University of Illinois has led to the development of a general purpose talking computer terminal. Such a terminal combines the advantages of ease and speed of use, freedom from dependency, and universality of application. Moreover, numerous psychological experiments show that, under proper conditions, auditory communication can be just as effective as written communication (4,5,6,7,8,9,10,12,15,16,22). The discussion that follows will explain how a talking computer terminal works and the history of the development of talking terminals at the University of Illinois.

First let us consider how a standard non-talking computer terminal for a sighted person receives and processes messages sent from a computer. Suppose the computer wishes to send the sentence "Have a nice day" for display on the terminal screen. The computer will send a series of groups of tones through a telephone line to the terminal. Each group of tones will be the code for a particular letter (just as a particular group of dots and dashes represents a particular letter in Morse code). As these tones reach the terminal, they are stored in a memory device in the terminal. A processor in the terminal decodes each group of tones. The code for the letter "H" is decoded into instructions to display an "H" on the terminal screen; the code for "a" is decoded by the terminal processor to draw an "a" on the terminal screen, etc. Each letter appears on the screen as soon as it is received and decoded. If the terminal has a typewriter printer instead of a video screen, the terminal translates each code into an instruction to an electric typewriter to type a particular key.

It would be possible to construct a primitive talking terminal for the visually handicapped along the following lines. Each letter code received from the terminal would be translated into a phonetic representation of the name of that letter, and this phonetic representation would be used to drive a speech synthesizer. Thus, for instance, the letter "v" would send the signal to make the sound "vee" to the speech synthesizer, the letter "n" would send the signal to make the sound "en" to the speech synthesizer, and so on. A talking terminal which could only pronounce one letter at a time would not be satisfactory, because it would be slow and because most blind users would prefer to hear words, not individual letters.

Recent advances in linguistic research and computer technology have made it possible to construct a different and better talking computer terminal, one that can translate the letter codes received from the computer into spoken words. This terminal works as follows. The individual letters received from a computer are stored at the terminal until a whole word has been received (The end of a word can be detected by the receipt of a space or a punctuation mark.). Then the processor in the terminal looks up the word in a series of rules and exceptions to find out how it is pronounced. It would find for instance that the word "nice" is an application of the rule that a final "e" is silent but makes the prceeding vowel long; it would find that "have" is an exception to this rule. Having found out how each word is pronounced the processor sends it out to a speech synthesizer connected to the terminal. Since all the words would be stored in the terminal, it is possible to allow the user to instruct the terminal to replay or spell any words he did not understand or wished to hear again.

In 1976, James Kutsch, while a graduate student at the University of Illinois, developed a talking computer terminal (11). The Kutsch terminal represented a major step forward toward the goal of equal access for the visually handicapped to computer-based media and has served as the inspiration for later work at the University of Illinois by Professor Peter Maggs in the development of improved prototype talking terminals.

While the Kutsch terminal solved the basic problem of a universal non-visual method for communication with computers, many issues remained for further research. In particular, improvement was needed in the quality of the synthesized speech, in providing the ability for the user to select a portion of the computer output to be spoken or repeated, to allow user options to have difficult passages spelled and easy passages spoken at an accelerated rate.

A talking computer terminal based upon the PLATO V programmable terminal developed at the University of Illinois (2)) was designed by Professor Peter B. Maggs with the assistance of Professor Bruce Sherwood, also of the University of Illinois. This terminal owed its inspiration to the Kutsch terminal, but involves several advances upon the techniques used by Kutsch. Another version has been built using a standard, unmodified Processor Technology SOL-20 microcomputer.

The talking terminal incorporates the results of new research on the automated translation of English to phonetic speech giving the capability of providing somewhat better speech more simply than with the methods used by Kutsch. It incorporates features allowing local repetition or skipping by the user of the material sent out by the computer. A totally new feature is the display of the text word by word in very large bright letters, to provide persons with vision too limited to read ordinary computer output the chance to see as well as hear the computer output.

This terminal uses methodology developed at the Naval Research Laboratory where a research group has developed a methodology for automatic translation from English to phonetics. The methodology combines the virtues of ease of implementation and high quality of results (3,9,14). It has been incorporated in the existing prototype terminals at the University of Illinois and the results have been very good. In addition to the high degree of accuracy with which it translates English text to phonetics, the approach used by the Naval Research Laboratory has a number of other major advantages. It is easily adaptable to use with any type of programmable computer terminal and any brand of speech synthesizer; the methodology is fully documented in Naval Research Laboratory publications; the methodology is in the public domain, free of any patent, copyright, or trade secret restrictions upon its widespread application. English presents a special problem because of its nonphonetic spelling. The terminal could easily be adapted for languages for languages with phonetic spelling such as Spanish, using techniques developed by Professor Bruce Sherwood of the University of Illinois (18).

Three alternative quality criteria might be applied to the quality of speech produced by speech synthesizers for use with a talking terminal. The first criterion is whether or not the synthesizer sounds like a live human speaker. No commercially produced speech synthesizer satisfies this criterion. The second criterion is whether or not the synthesizer can be easily understood on first hearing. At least one commercially available synthesizer, the VOTRAX VS-6 (21) passes this test for some, but not all listeners (14). The third criterion is whether or not the synthesizer is understandable after a period of getting used to its "foreign accent." Here in actual tests at least one commercially available synthesizer, the VOTRAX VS-6, has done very well in actual tests, and has achieved a level of intelligibility roughly equivalent to that of normal spoken English for users who have listened to it for half an hour (14).

It would certainly be desireable to have a perfect synthesizer. However it is believed that while the search for a better synthesizer should go on, research in how to use synthesizers to maximum advantage is of equal importance. First, because synthesizers are already good enough and cheap enough for blind persons to use them to great advantage; second because everything developed for use with the present generation of synthesizers will be easily adaptable for use with the next generation and will provide immediate applications for the improved synthesizers as they appear. While the need for a half-hour training period for use of synthesized speech is regrettable, the time and effort involved is trival as compared to that needed to learn Braille or the use of tactile device.

The prototype talking terminals developed to date at the University of Illinois have used the VOTRAX VS-6 speech synthesizer. This speech synthesizer provides a relatively high quality of synthetic speech. Experiments conducted at the University of Illinois with two less expensive types of speech synthesizers have been disappointing.

2. BENEFITS EXPECTED

Many American colleges and universities, with the University of Illinois in the forefront, are rapidly broadening the use of computer-based instruction. Unfortunately, to the extent that this instruction has taken the place of classroom hours, students with visual handicaps have been put at a disadvantage, because they have had to rely upon human readers to tell them what was on the video screens of the computer terminals used for instruction. It is hoped that the talking terminal will provide a partial remedy for this situation.

The remedy will only be partial because a high percentage of programs for computer assisted instruction use graphic displays as well as ordinary text, and these graphic programs will not be accessible even with the talking terminal. Nevertheless, the number of hours of instructional material made available will be substantial. There are about 6000 hours of instructional material available on the University of Illinois PLATO system, the largest system for computer assisted instruction in the United States, serving many educational institutions at all levels throughout the United States (18,19,20). Of these hours about 25% or 1500 hours do not make use of computer graphics, and thus would be immediately accessible with the talking terminal. There are also a total of some 15000 hours of instructional programs on other computer-based education systems in the United States. About 80% of these hours are not graphics oriented, amounting to about

12000 hours of instructional materials. Thus in all the talking terminal would give access to about 13500 hours of instructional material, increasing perhaps 100-fold the amount of computer assisted instructional material available to the visually handicapped in the United States.

3. OUTREACH

A major and continuing effort is being made to make the results of the project available for use by educational institutions throughout the United States. Every effort has been made in the design of the talking computer terminal to use standard components which can easily be plugged together in a few minutes. The goal has been to reduce the effort and skill necessary for others to make a talking computer terminal to be roughly the same as that required to buy an amplifier, turntable and loudspeaker at a stereo-high fidelity store and to plug the components together to make a stereo system

In order to make this possible, equipment has been chosen which is both standard and available from competing manufacturers. Thus all a prospective user has to do is to buy a standard microprocessor-based terminal available from local computer stores in every major city, have the synthesizer control program stored in a memory device attached to the processor, and plug in a speech synthesizer.

Educational institutions interested in constructing terminals for the visually handicapped should contact the author of this article at the University of Illinois College of Law for information on obtaining free copies of programs and terminal specifications.

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REAL TIME CAPTIONING

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1. INTRODUCTION

The Department of Health, Education, and Welfare is currently supporting an effort to make captioned television available to hearing-impaired citizens.

Several major projects are already underway. The most familiar is the ABC Captioned News, during which the daily 7:00 p.m. ABC Evening News program is captioned and then rebroadcast with captions after 11:00 p.m. Another project, and a very significant one, is the Closed Captions or Line 21 project. This continuing effort is aimed at delivering captions, with standard television broadcasting techniques, only to those who wish to see them. To facilitate this effort, the Federal Communications Commission (FCC) has set aside one of the timing and control lines of the video frame to carry text information for captions. To take advantage of the FCC's efforts, the home receiver must be equipped with a special device--a decoder--that extracts and interprets the codes in Line 21 and generates corresponding characters on the screen. This method of captions is being tested routinely at several schools for the deaf around the United States, and several hours of programming are broadcast each week over the PBS network. The captions are developed for video taped programs using an off-line method. Production versions of the Line 21 encoder to be used by the broadcaster and the Line 21 decoder to be used at the home receiver are currently under development.

While these, and similar projects, have greatly advanced efforts to develop routine captioning methods, none have dealt with the problem of captioning live shows. Although much of standard commercial and public television is video taped, many special events such as political events, news, and sporting events are broadcast live.

This paper describes a project at Teledyne Geotech that aims to utilize the Line 21 technique for real-time captioning. The paper is organized into several sections. Chapter 2 gives an overview of the system. Chapter 3 gives the hardware/software design of the system, including the specially modified stenotype, the microcomputer controller, the stenotype-to-English translator, and all subsystem interconnections. Chapter 4 gives the plans for evaluating the effectiveness of the system.

2. OVERVIEW

Recently Stentran Systems, Inc. developed a proprietary computer translator which converts stenotype records to English text. The system was designed to produce transcripts and it is routinely used for that purpose. A stenotypist, whose writing style is clear and accurate, transcribes the speech on an Electronic Shorthand Transcriber (EST), which is a specially modified stenotype that produces the usual paper notes, but has the added capability to record those notes in computer-readable form on cassette tape. The computer-readable notes are then fed into the computer translator containing the stenotypist's individualized dictionary.

While accuracy of the output English text varies with the stenotypist, the unedited English text can be at least 95 percent accurate and often as high as 99.5 percent accurate. Normally transcriptions are edited to yield 100 percent accuracy. Typically, translation is performed at a rate greater than 225 words per minute. With stenotypists also able to enter data that fast, the translation process can follow normal speech in real time. Teledyne Geotech and Stentran Systems are employing the Stentran translator in a microprocessor controlled network of electronic equipment to provide real time captioning.

All components are interconnected through a central microcomputer controller called the Master Interface System (MIS). It functions as the center of a star-shaped network (see Figure 1).

The EST has been modified to replace the cassette recorder with a direct connection to the Master Interface System. The MIS reads the keystroke data from the EST and buffers it, if necessary.

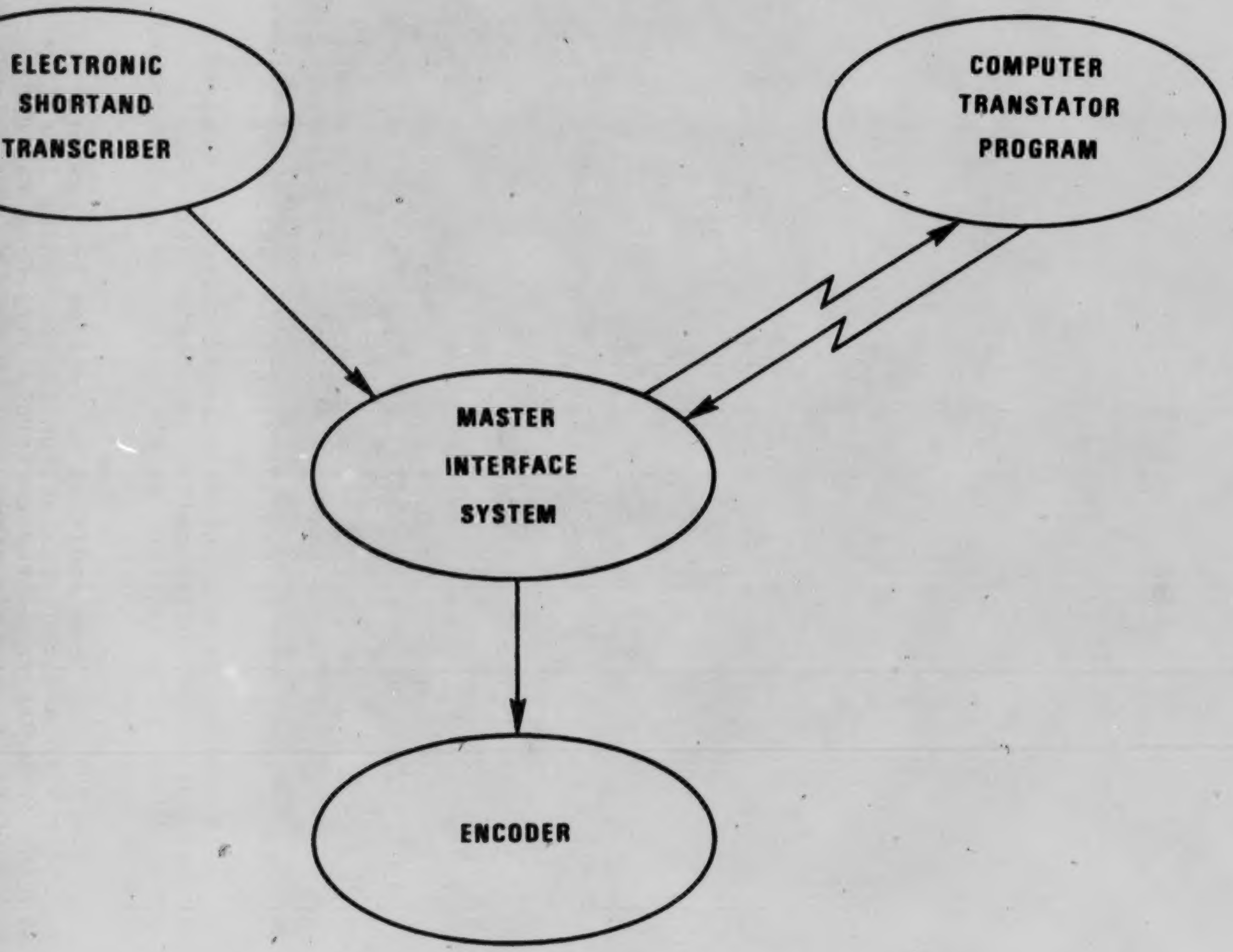
ELECTRONIC
SHORTAND
TRANSCRIBER
COMPUTER
TRANSTATOR
PROGRAM
MASTER
INTERFACE
SYSTEM
ENCODER

FIGURE 1 STAR NETWORK OF EQUIPMENT

The translator program runs on a large IBM 370 computer. The Master Interface transfers the stenotype keystroke data to the translator program and receives the English text back from the translator program. This interconnection is a standard dial-up character-oriented communication link using the public telephone network and standard adapter equipment for computer data transmission. This link operates at slightly less than 120 characters per second. Data is transmitted in only one direction at a time.

In the IBM 370 computer, a special communications handler keeps the flow of data moving smoothly so that new keystroke data can be transferred into the IBM 370 from the MIS while the translator is processing the previous unit of keystroke data.

When the MIS receives English text back from the translator program, it is buffered, if necessary, control codes are added as necessary, and the text and display controls are transferred to the encoder over a short cable.

In a live broadcast situation, the stenotypist will be listening to and viewing a television monitor of the broadcast. This monitor will be located in a quiet area, protecting the stenotypist from distractions. The stenotypist records the audio portion of the program verbatim on the specially modified EST. The codes go through the network of equipment described above; Figure 2 illustrates this configuration.

For the demonstration system, we have simplified the procedure. Instead of watching a program being broadcast on a monitor, the stenotypist will be listening to and watching a video tape being played on a monitor, simulating a live broadcast monitor. Processing occurs when keystroke data enters the network and text is transferred to the encoder, as if broadcast live. However, the output of the encoder is not broadcast but rather is transferred directly to a decoder (described earlier) that converts electronic signals to characters on the television screen. The contents of this screen, a second monitor, are simultaneously recorded to yield a video tape containing captions as seen on a home receiver equipped with a decoder. However, because these captions are now part of the picture, they can be seen when the

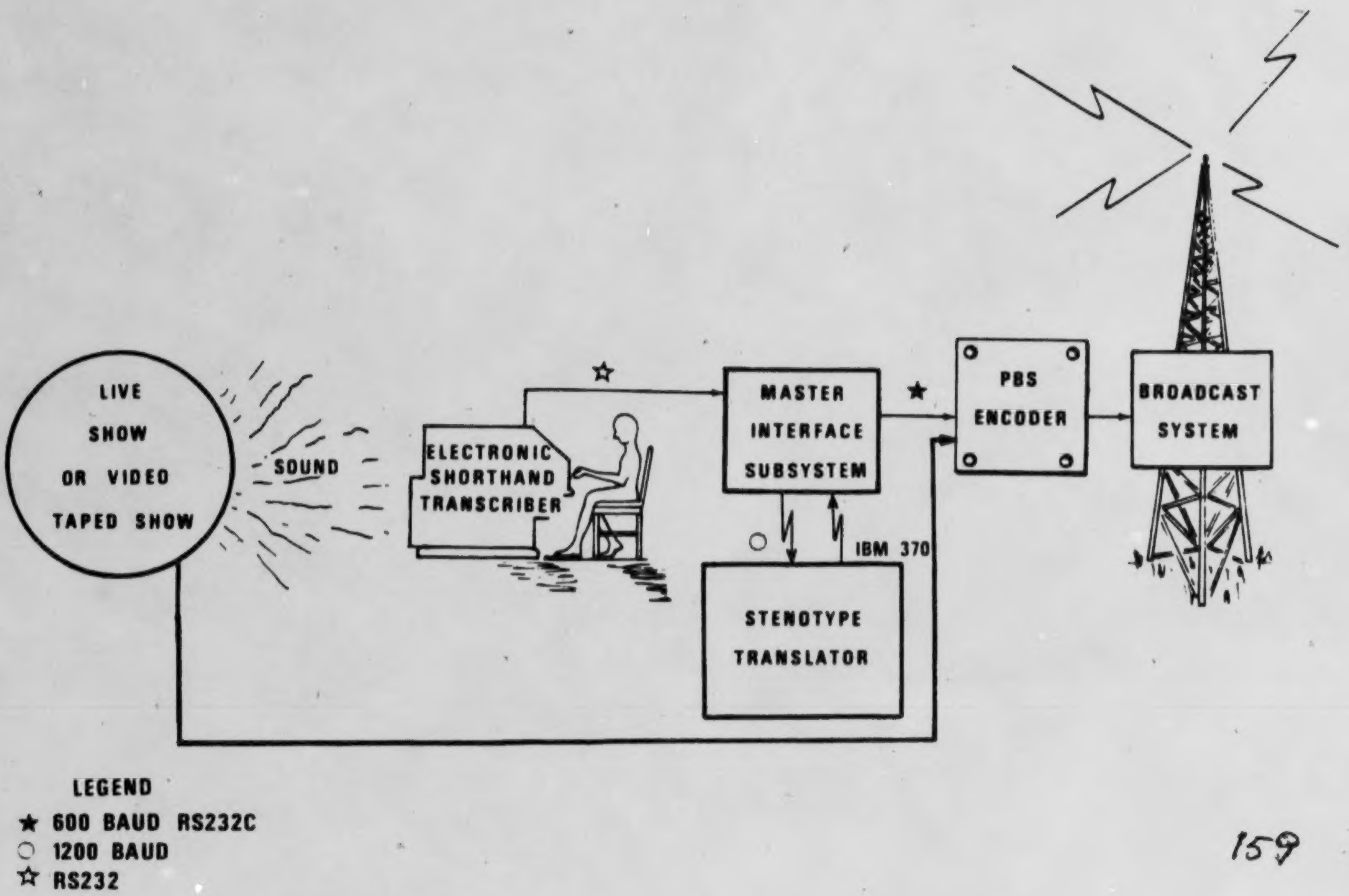
LIVE
SHOW
OR VIDEO
TAPED SHOW
SOUND
ELECTRONIC
SHORTHAND
TRANSCRIBER
☆
MASTER
INTERFACE
SUBSYSTEM
○
IBM 370
STENOTYPE
TRANSLATOR
★
PBS
ENCODER
BROADCAST
SYSTEM
LEGEND
★ 600 BAUD RS232C
○ 1200 BAUD
☆ RS232

FIGURE 2 OPERATIONAL CONFIGURATION

video tape is played on any ordinary video tape player. This method is designed to simplify the task of showing captioned programs to hearing-impaired audiences for evaluation purposes; Figure 3 illustrates this process.

The original prototype of the encoder/decoder that we are using permits neither scrolling nor display of one word at a time. The encoder/decoder has the ability to display three lines of 32 characters each on the lower 1/3 of the television screen. The characters are always white against a black rectangular background. Only upper case characters are used.

Given the limitations of caption format control imposed by our encoder/decoder, the system displays three lines at once. When the next three lines are available, they are displayed and so on.

3. DEMONSTRATION SYSTEM DESIGN

3.1 DESIGN OBJECTIVES

The system, actually a network, interconnects a suite of operational hardware/software systems to provide the necessary continuous data path from stenotype machine to encoder. Because the configuration is a demonstration system, we wanted to minimize the development effort. We also wanted to minimize risk. To fulfill these two objectives, we designed with the intent to minimize new equipment and software. Higher operation costs and inconvenience in running the system are two consequences of these objectives.

Further, we invested no more than the necessary amount of effort into error recovery and ease of restarting.

Two features in this demonstration version are expected to need future modification. First, the current system discards new, rather than old data when a communication backup develops. The opposite should be true in an operational system design. Second, in this version, stenotypist errors that prevent unambiguous translation are discarded. In an operational version, one of several possible words should be displayed. In the case of impossible translation, the phonetic character string probably should be displayed. The viewer would then have the opportunity to determine what was said.

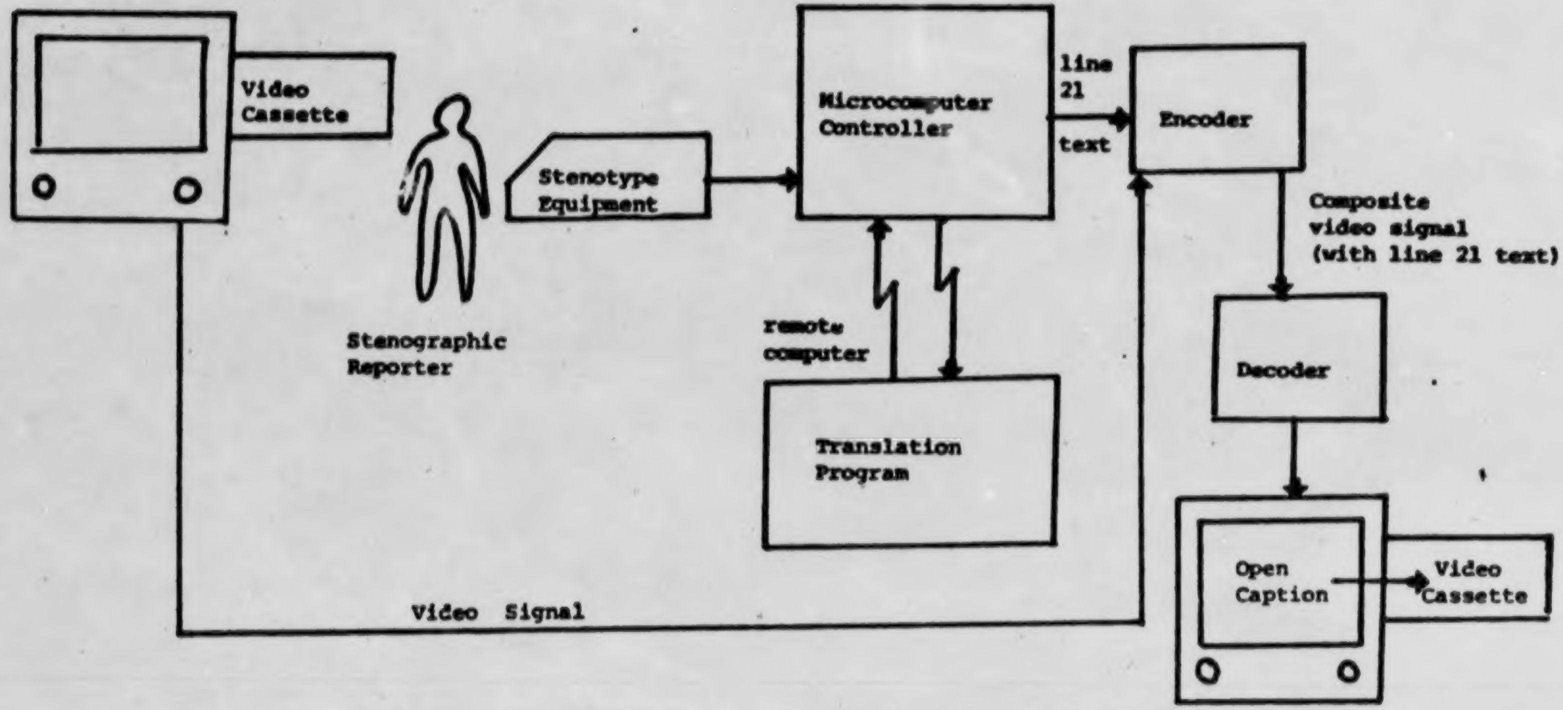
Video Cassette
Stenographic Reporter
Stenotype Equipment
Microcomputer Controller
line 21 text
Encoder
remote computer
Translation Program
Composite video signal (with line 21 text)
Decoder
Open Caption
Video Cassette
Video Signal

Figure 3. Demonstration System Configuration
Except for the remote computer, all equipment is in one location.

3.2 THE STENOTYPE MACHINE

Using a modified machine, the stenotypist enters standard stenotype keystrokes representing the audio portion of the television program. The model normally used by Stentran Systems, Inc. is equipped with a cassette recorder (the EST). However, for this project the cassette recorder has been replaced by an M6800 microprocessor based interface that converts the keystroke data normally recorded on cassette to an RS232-C format bit-stream. Each stroke is preceded by a special 8-bit code and followed by an 8-bit code. The RS232-C output port is connected by means of a short cable to the MIS. A transfer rate of 1200 bits per second is used (see Figure 4).

3.3 MASTER INTERFACE SYSTEM

The MIS is the central control for the real time system. It receives stenotype keystroke data as primary input. The MIS controls the communication links with the IBM 370, formats and transfers to the encoder the caption text.

The MIS hardware consists of an Intel SBC 80/20 MULTIBUS microcomputer system. It has five serial I/O ports and two 8-bit parallel I/O ports, and the processor is an Intel 8080A. There are 4K bytes of Read Only Memory for program storage, and 4K bytes of Random Access Memory for data buffer and variables.

A keyboard terminal attached to the MIS is used to initiate communication with the IBM 370 remote computer. This same terminal when equipped with cassette can record the stenotype keystrokes or caption text for test and verification purposes.

The MIS software is organized into four major units. The first section reads and buffers keystroke data from the EST. The second section controls the transfer of keystroke data over the communication link to the IBM 370. This section is coordinated with the third section that receives and buffers caption text data from the IBM 370. The fourth section controls ASCII text and control character output to the encoder. Figure 5 illustrates the general program organization.

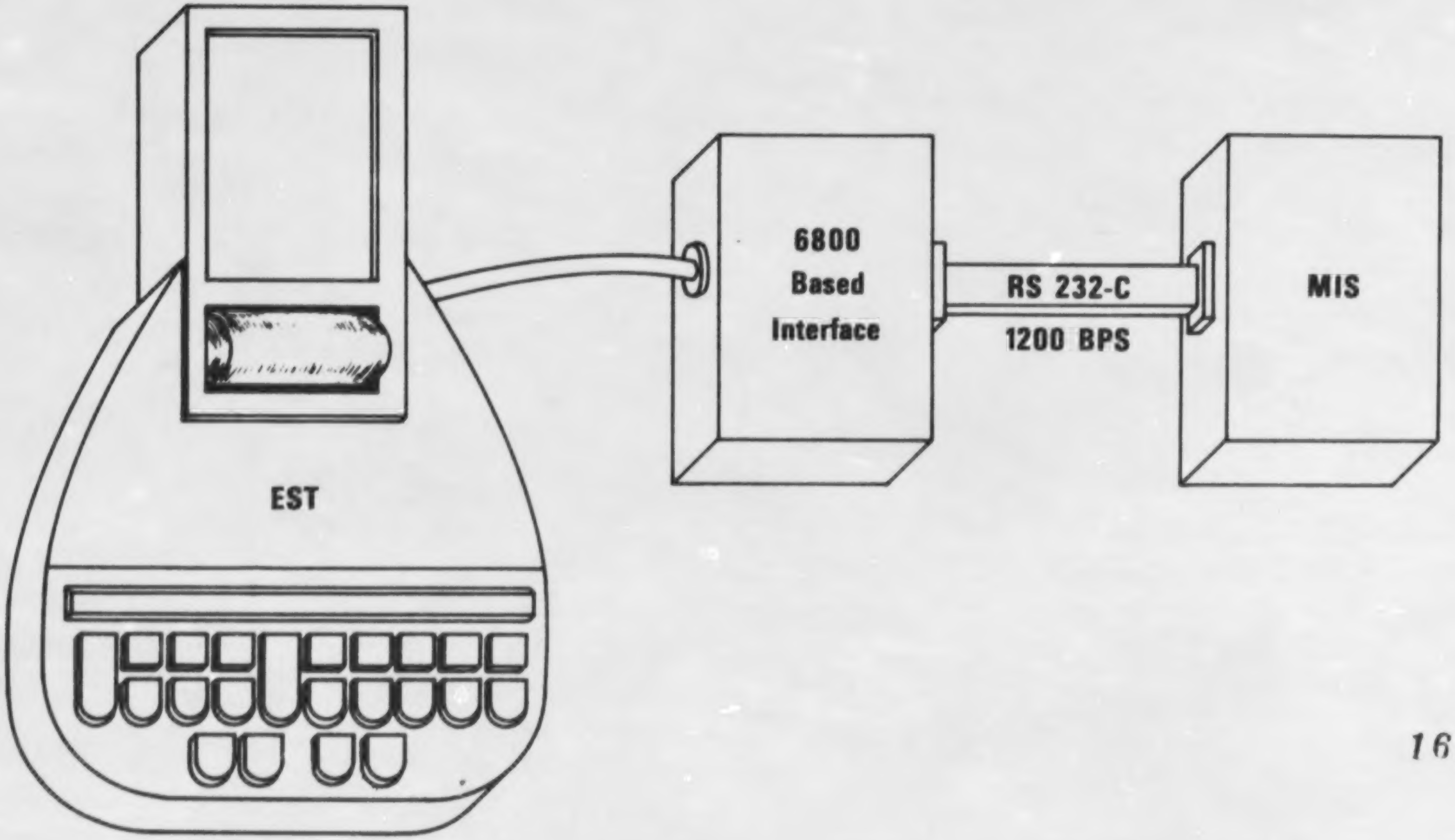
EST
6800
Based
Interface
RS 232-C
1200 BPS
MIS

FIGURE 4 EST INTERFACE TO THE MIS

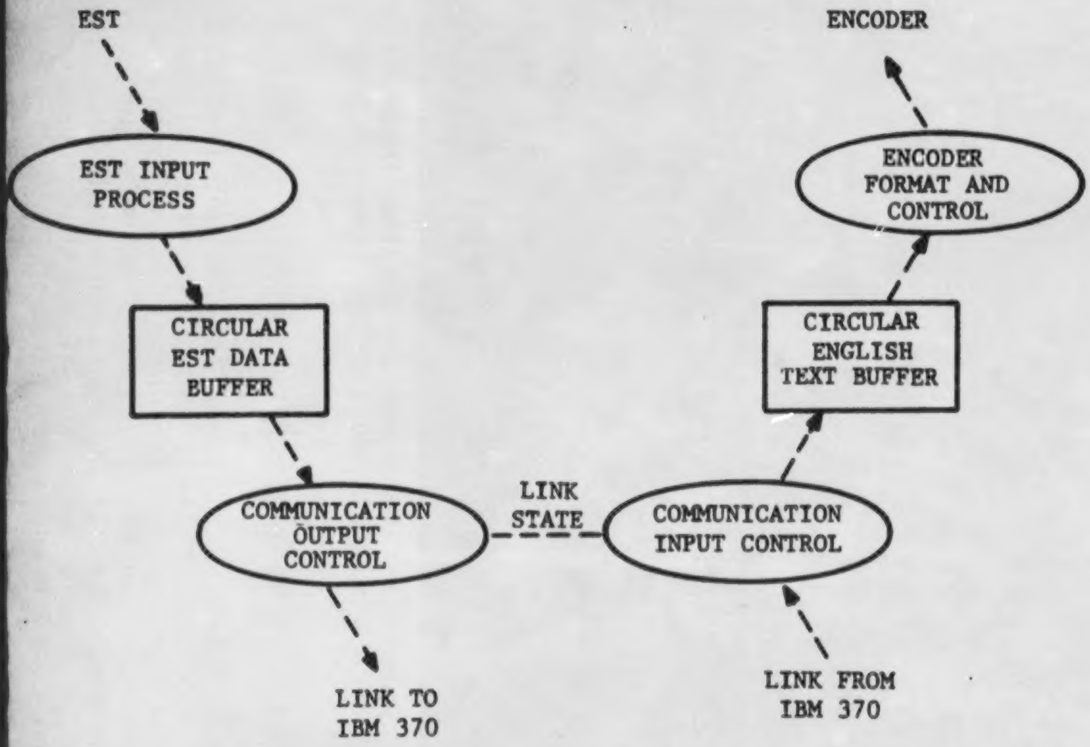
EST
EST INPUT PROCESS
CIRCULAR EST DATA BUFFER
COMMUNICATION OUTPUT CONTROL
LINK TO IBM 370
LINK STATE
COMMUNICATION INPUT CONTROL
LINK FROM IBM 370
CIRCULAR ENGLISH TEXT BUFFER
ENCODER FORMAT AND CONTROL
ENCODER

FIGURE 5 MIS INTERNAL SOFTWARE ORGANIZATION

3.4 IBM 370 PROGRAM

The automatic translation program runs in the Time-Sharing Option (TSO) partition of the IBM 370 remote computer. Communications between the translator and the MIS is like that between TSO and a terminal.

The automatic translation program is organized as two tasks: the translator task and the communications task.

The translator task consists of the normal operational translator that has been reorganized. Normally, the first phase of the program processes all data for an EST cassette corresponding to several hours of transcription and stores the English translation in an intermediate disk form. Then, the second phase of the translation reads the disk file and produces the final English output file. The reorganization of the software allows a group of strokes representing one translation unit to be completely processed through both phases before the next unit is read.

The input is read by a subroutine that interfaces with the communications task.

The output is written by a subroutine that also interfaces with the communications task. This subroutine compresses the English text blocks by deleting those fields not used in real-time captioning.

The communications task issues the input/output requests as appropriate to the TSO terminal input/output handler.

3.5 FORMATTING TEXT FOR THE ENCODER

The message containing the caption text returned from the translator has a code associated with it. This code indicates such conditions as end-of-sentence, paragraph, start-of-underline, initial single quote and final single quote. The MIS inspects each code and forces a new line or display when end-of-sentence, paragraph, new page, and similar codes are present.

As mentioned earlier, three lines are displayed on the screen, when another three lines are available, they are displayed, and so on. Whenever there is a time delay of more than about three seconds, the MIS displays whatever text is ready, regardless of whether it composes a complete thought. When the next data is available it is displayed on a new screen.

The decoder can be imagined to have two buffers inside: one into which text is placed as it is received and one containing the text being displayed on the screen. Each buffer is three 32-character lines.

To position captions on the screen, the controls available are: 1) start a new line and 2) exchange two buffers so the buffer previously receiving data is now being displayed. This is done by changing the identity of the two buffers. Given this control capability, the most direct caption format is as follows: 1) transmit three lines, display those three lines, and transmit three more lines while continuing to display the previous three lines, 2) exchange the buffers thus changing the display and repeat. Figure 6 shows two successive displays illustrating the positioning of lines on the television screen. The picture, of course, appears as on any home television receiver, independent of the captions.

Each different caption display remains on the screen until the next caption display has been received. This caption display stays on the screen until shortly after the next portion of speech to be displayed has been spoken because that is the time required for the next caption display to be entered, translated, and transmitted. There is no forced minimum or maximum time for a particular display to remain on the screen. Any display remains until the next display is ready, giving the maximum time possible for reading captions.

4. EVALUATION

4.1 INITIAL EXPERIMENTATION

The new system should be tested in an operational environment, thus discovering its strengths and weaknesses and determining ways to accommodate these during routine system use. During an initial operational period, we may find that minor refinements are needed in the demonstration system.

Similarly, to develop a useful evaluation tool, familiarity with the operational features of the system

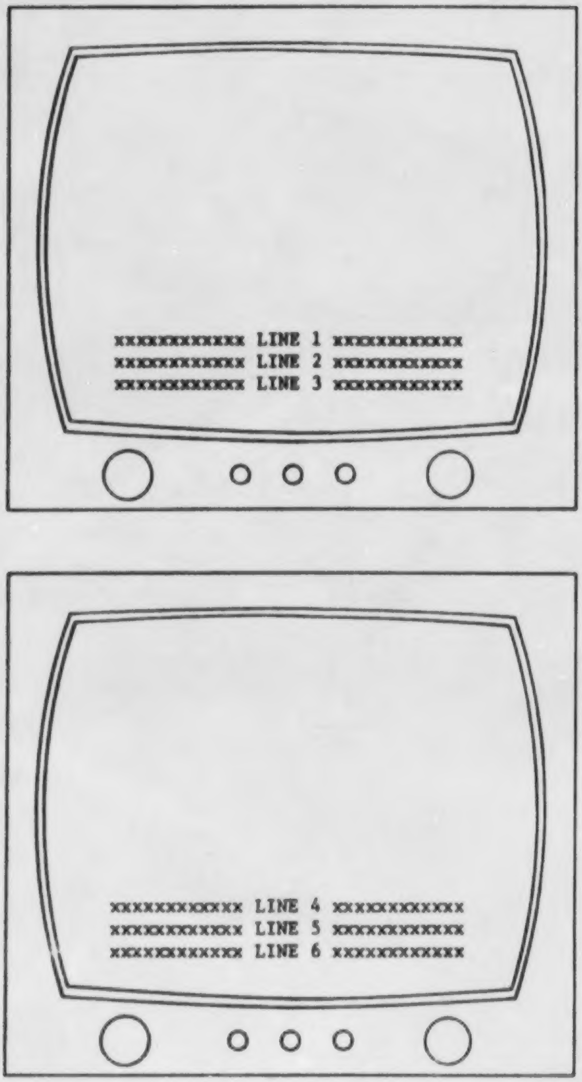
xxxxxxxxxxxx LINE 1 xxxxxxxxxxxx
xxxxxxxxxxxx LINE 2 xxxxxxxxxxxx
xxxxxxxxxxxx LINE 3 xxxxxxxxxxxx
xxxxxxxxxxxx LINE 4 xxxxxxxxxxxx
xxxxxxxxxxxx LINE 5 xxxxxxxxxxxx
xxxxxxxxxxxx LINE 6 xxxxxxxxxxxx

FIGURE 6 CAPTION FORMAT

is necessary. During this initial operational period, we also plan to devise distinct caption treatments to be used in the formal evaluation.

Thus, we plan to systematically experiment with the system for a period of from four to six weeks. During this period, we will measure how close to real time the stenographic reporter can enter data, and we will analyze the error rate against delay time to determine some practical limits.

We plan to experiment with minimizing the number of words to be treated as one translation unit by the translation program.

Finally, we plan to experiment with the stenographic reporter's attempt to edit the speech to make it more comprehensible to those with impaired hearing. An example of this editing is changing passive voice to active voice. Another example is changing the occurrences of "if" to "when". At this writing, we have not used the system and do not know exactly what is achievable in these areas.

4.2 TEST DESIGN

There are two aspects to the question of how captions are useful to the hearing-impaired. First, captions must assist the audience in understanding what is going on in a television program. Comprehension is surely necessary for better enjoyment of television by the audience. Second, the captions themselves must be visually pleasant and not irritating to the viewer. Therefore, we have chosen two measures of effectiveness; 1) comprehension improvement between uncaptioned programs and programs captioned with our real-time captioning system and, 2) improvement in positive attitude toward the captions between uncaptioned programs and programs captioned with our real-time captioning system.

We will quantify each of these two measures on a scale of 1 through 10. We will take as an overall score or measure the average of each taken separately. These scales were chosen as a reasonable number of different facts that could be tested for in a half-hour drama/comedy. While we may be able to improve on this scale with news shows, the scale of 1 through 10 offers a reasonable worse case to use in computing necessary sample sizes.

To determine the amount of comprehension improvement expected, we conducted a literature search. In summary, a review of the literature concerning the relationship of captions to comprehension reveals that captions on motion picture films or television programs increase comprehension of the content of the films for most deaf students regardless of grade level, when the films selected are of appropriate grade and reading levels. However, a percentage of deaf students on each level does not possess the reading skills necessary to benefit from captions.

We assume that the usefulness of the captions measured as the change in level of understanding and positive attitude will vary with the degree of hearing impairment, reading level, and previous experience using captions. Therefore, we must treat each skill level (hearing, reading, and experience) separately. This division will allow us to obtain an effectiveness measure for several levels of hearing, for several levels of caption experience, and for several reading levels.

We expect the greatest improvement in comprehension and positive attitude among the profoundly deaf with the highest experience level and highest reading level. Conversely, the smallest improvement is expected among the moderately hearing-impaired with no caption experience and lowest reading level.

To overcome the audiences lack of experience in watching captions, we plan to have a period of audience viewing with captions before the formal testing to help the audience become accustomed to using captions.

The question of differing skill levels among audiences is unimportant because we will have a control treatment used as a base line. Thus, such things as previous caption viewing and education, which might affect a person's score on a comprehension questionnaire, need not be considered because we will have their scores on the non-captioned programs. Our plan is to complete a pretest and, then use that data to develop the final test design.

The experimental plan for the pretest assumes that we are interested in the four factors: experience with captions, degree of hearing impairment, type of show, and type of caption (no caption, delay 1, delay 2). Each of these four factors will be observed at three levels so that we have 3^4 or 81 possible treatment combinations for the full factorial arrangement. A further condition is that we wish to carry a reading score along as a covariate.

It seems reasonable to use a fractional replication given that two-factor interactions are expected to be negligible and that we wish to estimate main effects with reasonable precision. Furthermore, we expect that there will be some difficulty in obtaining subjects for each of the 81 treatment combinations.

A Latin Square, or more precisely, a 3 x 3 Greco-Latin Square (Cf. (1), p. 274) would be a 1/9 replicate of a 3^4 factorial requiring only 9 observations, (see Figure 7). The difficulty is that main effects will be contaminated with two-factor interactions (if there are any) so that this arrangement is unnecessarily risky.

A more satisfactory fractional factorial would be the 1/3 replicate of the basic 3^4 given in Figure 8 (Cf. (1), p. 290) which enables us to estimate main effects uncontaminated by two-factor interactions with only 27 observations. This design will also allow a significance test for all two-factor interactions involving three of the four factors. Thus, we need only assume that the interaction of experience with each of the other three factors is negligible. If additional precision is needed for estimating the caption main effect, additional replications of the basic design may be considered. The main objectives of the pretest are:

1. to determine if any factors are unimportant so that they can be eliminated from the central design.

2. to estimate the experimental error variance and the approximate magnitude of the caption effect so the sample size for the main experiment can be determined.

3. to assess the possibility that interactions between hearing impairment, type of show, and type of caption could be significant.

The analysis of variance given in Figure 8 should provide the basic data for developing the final test design.

		Group 1	Group 2	Group 3
		E_1	E_2	E_3
Session 1	S_1	C_1 I_1	C_2 I_3	C_3 I_2
Session 2	S_2	C_2 I_2	C_3 I_1	C_1 I_3
Session 3	S_3	C_3 I_3	C_1 I_2	C_2 I_1

E_1, E_2, E_3 represent three levels of experience with captions

I_1, I_2, I_3 represent three degress of hearing impairment

S_1, S_2, S_3 represent three types of shows

C_1, C_2, C_3 represent three types of captions (no captions, delay 1, delay 2)

Figure 7. Greco-Latin Square

Factors Levels

Experience (E) 1,2,3
Impairment (I) 1,2,3
Show Type (S) 1,2,3
Caption Type (C)1,2,3

Analysis of Variance

Source	d.f.
E	2
I	2
S	2
C	2
IS	4
IC	4
SC	4
Reading (R)	1
Error	5
	26

Treatment Arrangement

Obs.	E	I	S	C
1	1	1	1	1
2	1	2	3	3
3	1	3	2	2
4	2	1	3	3
5	2	2	2	2
6	2	3	1	1
7	3	1	2	2
8	3	2	1	1
9	3	3	3	3
10	1	1	3	2
11	1	2	2	1
12	1	3	1	3
13	2	1	2	1
14	2	2	1	3
15	2	3	3	2
16	3	1	1	3
17	3	2	3	2
18	3	3	2	1
19	1	1	2	3
20	1	2	1	2
21	1	3	3	1
22	2	1	1	2
23	2	2	3	1
24	2	3	2	3
25	3	1	3	1
26	3	2	2	3
27	3	3	1	2

Figure 8. Recommended Design for Pretest

5. CONCLUSIONS

The application of computerized shorthand transcription to television captioning is clearly a major technological advancement in providing these and similar services. There are numerous related applications that can benefit. Such a real-time system might be used to provide a word display for conferences and committee meetings involving the hearing impaired. The system might also be used for economic large scale offline video or film captioning or for large scale computer text entry.

After making the system more robust and optimizing accuracy and delay tradeoffs, the next step is to develop the operating procedures to use the system most effectively.

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TEACHING LANGUAGE/COMMUNICATION SKILLS TO DEAF CHILDREN BY MEANS OF CAI*

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In the present project we are dealing with Computer Assisted Instruction (CAI) of young, deaf (80dB or worse), children. The project relies upon the computerized implementation of a curriculum developed originally for deaf multi-handicapped children, viz., Building Blocks for Developing Basic Language (Peterson & Schoenmann, 1977). This curriculum, which is based on the first five sentence patterns in Apple Tree (Caniglia, Cole, Howard, Krohn & Rice, 1972), provides an orderly sequence of objectives for learning basic language skills. However, in the present project we are studying only the first two sentence patterns in Apple Tree: (1) Noun + Verb(be) + Adjective; (2) Noun + Verb(be) + Where. These sentence patterns are usually taught first since they deal with simple concrete experiences using familiar objectives and employ easily demonstrated characteristics such as color, size, physical location, etc.

As an additional aid in teaching language skills, the Building Blocks for Developing Basic Language curriculum uses color as a means of coding different grammatical parts of speech. Thus, color prompts can be used to facilitate the proper placement of nouns, verbs, and adjectives in forming sentences. In order to implement this particular feature of the curriculum on a computer, it is of course necessary to have color-graphic capabilities. Such capabilities, in addition to providing color prompts during sentence formation, provide an opportunity for interesting displays that should serve to increase motivation in the learning task.

The main processor in the present project consists of a Data General NOVA 3/12 minicomputer, with 65K bytes of core memory storage, a 10 megabyte hard disk, analog-to-digital and digital-to-analog converters, etc. Adequate core storage is required to handle the many branches and conditional instructions required in CAI; large volume disk storage is required to store graphic vectors and digitized speech signals; the converters are required to process speech signals. An important feature of this system is disk access times which are on the order of only milliseconds.

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The color-graphic terminal consists of a Ramtek 6000 Micrographic system. This is an "intelligent" terminal which utilizes a simplified instructional format in generating complex graphic displays. The pattern of these displays, including a variety of 16 colors, are simply represented as Fortran Format statements in the NOVA computer. These are read from disk storage and transmitted to the color-graphic terminal for execution. Resolution on the screen is 512 by 256 individually addressable display points, which provides for quite good graphic quality.

The child has essentially three methods of responding to the computer displays. First, the child can touch a series of keypads located around the periphery of the screen (these line up with response displays). Second, the child may respond through a keyboard, i.e., letters and words may be typed. Finally, the child may produce manual signs which are evaluated by a teacher or teacher's aid who can indicate to the computer either a correct or incorrect response by means of a switch.

Because many deaf children have some degree of residual hearing which can benefit from amplification, we felt it was important to automate a procedure which presented speech in close temporal relationships to the various alphabetic letters, words and communication signs displayed on the computer terminal. Original speech signals (spoken letters, numbers and the various words that comprise the dictionary, e.g., the word "red") are amplified and then sampled by the analog-to-digital converter at a rate of approximately 10,000 conversions/sec. Speech reproduction is achieved by passing the stored digital values to the digital-to-analog converter at exactly the same rate as the original analog-to-digital conversion. The signal is then shaped by filtering (to eliminate high frequency noise and problems of frequency aliasing, etc.) and then passed finally to earphones. The quality of such computer speech is quite good, depending of course upon the sample rate (higher rates improve the quality of the signal).

One of the main features of the graphic display system is the ability to present high resolution 2-dimensional illustrations of manual communications signs and fingerspelling hand positions. Graphic resolution on the Ramtek terminal is sufficient to achieve the desired quality of display. A more practical matter concerns the means by which the many X, Y coordinates that define a given display are determined. There are, of course, very tedious manual methods such as reading coordinates from graph paper. In the present study we utilize a digitizing tablet that permits one to simply trace the outline of a line drawing with a stylus that then transduces the X, Y coordinates and communicates them automatically to the computer.

The initial CAI experiment compares an experimental and control group matched for age, sex, hearing loss, and academic achievement (assessed by means of a pretest). The control group will receive individualized instruction from a teacher trained in the use of Building Blocks for Developing Basic Language. The experimental group will be exposed to CAI at the same time the matched control children receive their instruction. Each student will interact with the computer terminal for approximately ½ hour each day.

Students will progress through the instructional sequences designed to teach vocabulary, categorization skills, sentence structures and question forms. Display formats will include various combinations of object drawings, printed words and sentences, graphic displays of manual communication signs and/or fingerspelling hand positions presented in sequence.

The primary dependent variable will consist of group scores on a posttest of language skills. If CAI is effective, then the experimental group should show significant improvement as compared with the control group. There are, however, additional dimensions to be considered. An important aspect of the present project will be to determine if CAI results in increased levels of motivation (assessed perhaps by the amount of time a child will voluntarily interact with the computer terminal). Also of importance is the potential usefulness to the teacher of performance profiles. Finally, there is the vital question of how the computer system affects the classroom teacher and whether or not teachers react favorably to the entire enterprise.

It is our hope that CAI will assist the deaf child in acquiring language and reading skills, thus helping to reverse the trend of low academic achievement among many deaf children. Initially we are approaching this task with a prototype system that involves an on-site computer interacting in a one-on-one situation with a given deaf student. However, if the prototype concept is shown to be effective, then it becomes a relatively simple matter to expand to multiple terminals which communicate to a single host computer via telephone lines---essentially a consortium of CAI for the deaf. With the increasing availability of inexpensive microprocessors, and the new audio/visual storage and display technologies it is possible to fore-see a time when extremely elaborate (yet relatively inexpensive) CAI programs could be available in the home. Such technological advances may well spell the onset of new educational achievements among the deaf.

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Computer-Based Experiments Using the von Restorff Phenomenon to Teach Mentally Retarded Persons

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There are approximately 6 million mentally retarded persons in the United States, very few of whom have come in contact with, or have had the opportunity to benefit from, computer technology. Although computers are an excellent mechanism for presenting information in a redundant manner and giving immediate reinforcement, two factors which are essential to efficient learning in retarded persons, they have not been so used to any significant degree. In fact, reports of the use of computers to aid learning in the mentally retarded have been meager.

The few studies that have used a computer to improve learning in the mentally retarded (see, e.g., Winters, Hoats & East, 1978) were conducted with large computer systems, either in an institutional setting or in a noninstitutional setting where the mentally retarded were usually part of a larger sample of handicapped persons. Most of the reported studies were concerned with teaching a single subject (e.g., arithmetic or spelling). With the exception of one study (Nelson, 1972), none used an experimental design to evaluate the differences in learning in the mentally retarded, compared with either non-CBI instruction or with a nonretarded group. We found no study that examined the possibility of improving performance by applying a basic law of learning that is known to facilitate learning performance in the mentally retarded.

Kearsley (1977) has commented on the absence of exchange of ideas and information between workers in CAI and in cognitive psychology. This lack of exchange is unfortunate in that the interests of these two groups are similar (problem solving, information processing, concept formation, etc.), and there may be much redundancy of effort and information. Following Kearsley's lead, we will attempt to determine whether information processing can be facilitated in mentally retarded persons, using a microcomputer in an experimental learning environment. In our first series of experiments, we will investigate the efficacy of a venerable and effective phenomenon of learning: the von Restorff effect

The von Restorff phenomenon (von Restorff, 1933; Koffka, 1935; Kohler, 1938; Wallace, 1965) is demonstrated when a unique, heterogeneous item that is embedded within a list of otherwise homogeneous items during initial learning, is recalled better than a homogeneous item in the same position in a control list. Some examples might include a word printed in red in a list otherwise printed in black, a word printed in capital letters among words in lower case letters, or a number placed within a list of letters. The effect has been thoroughly investigated (Wallace, 1965) and has been shown to be robust and invariant. Investigations with retarded persons have shown that they are susceptible to the effect in both the visual (McManis, 1966; Sternlicht & Deutsch, 1966) and auditory (Winters & Attlee, 1974; Winters & Ward, 1975) modalities. As with nonretarded persons, overall list learning is not often improved when this learning phenomenon occurs, but predictions as to which specific information or items are to be learned are relatively accurate.

Typically, studies investigating the von Restorff phenomenon have presented materials for initial learning either in vertical-format printed lists or sequentially (flip cards, memory drum), requiring recall of all information. Since the memory system of the retarded person is overloaded, overall recall is poorer than in nonretarded persons, but the unique items are learned with equal efficiency by both groups. In the series of studies that we plan, the initial information will be presented in a sentence format and subjects will be tested for the learning of specific content. Thus, it may be possible to select beforehand what information is to be learned, and to teach that information in an interesting and familiar manner. What follows is a specific description of a series of studies that will be conducted with mentally retarded children, using a microcomputer to teach them via the von Restorff phenomenon. At present, we plan to present unique words in upper-case letters, with homogeneous words presented in lower case, as the isolating characteristic. Each experimental condition will have a control condition in which the exact same sentences will be presented in lower case letters. Tests of learning will require the subject to select the appropriate answer in a multiple-choice paradigm, either in response to a question or by sentence-completion.

In the first series of studies, we will attempt to determine the fewest number of words that are required in a sentence to attain maximum learning of the isolated item. In other words, given one unique word in a sentence, we will investigate what is the minimum number of other words required for the information to be learned. It is apparent that, given many other homogeneously printed words, the unique item will stand out and be learned. However, too many homogeneous items (a) will overload the memory processes of the mentally retarded and (b) other to-be-learned information may be embedded within the homogeneous items and not be learned. Our purpose here is to determine the maximum amount of transfer of information within the smallest unit or context of information, so that we can determine and stabilize sentence length while optimizing the processing of information.

Our second series of studies will investigate how many isolated items can be included in a sentence, given a specific sentence size, so that the greatest amount of information is communicated. Thus, if a sentence has eleven words in it, can we include two or three isolated items and assure improved learning of those items? Obviously, increasing sentence length will permit an increasing number of unique items, whereas, too many unique items in a sentence will attenuate the learning phenomenon because the items lose their distinctiveness. Too few unique items may result in the learning of the relevant information but, again, may overload the memory system and the children may not utilize information that is embedded within the homogeneous portion of the sentence.

Given that we can determine (a) the minimum number of words in a sentence that will cause maximal recall of one isolated item and (b) the maximum number of unique items that can be adequately processed given a minimum number of words in a sentence, we would hope to be able to establish some ratio between unique and homogeneous items in a sentence that would enhance the learning of specified information with varying sentence size. We have no idea if this ratio is constant, regardless of sentence size, or changes proportionately, logarithmically, or otherwise with increasing sentence size. Whatever the finding may be, if this ratio can be determined, then it should be generalizable to other learning environments where CBI is used.

The last in this series of experiments is concerned with the location of a single unique item in a sentence. Traditionally, a unique item has been placed in or near the middle of a list. The reason for that central location is that items from the middle portion of the list are not learned as well as items in the beginning or latter portion of the list. This is referred to as the "serial learning curve" (Osgood, 1953). In order to demonstrate that the isolated item was learned better than a control item in the same list position, there must be room for improvement. When placing an isolated item in the beginning of a list, the primacy effect leaves little room for improvement; when placing an isolated item at the end of a list, the recency effect leaves no room for improvement (McGeoch & Irion, 1960). These effects however, are due to the use of a single list presentation used in the traditional paradigm investigating the von Restorff phenomenon.

When a series of lists or sentences are given, all of the units form a serial learning curve. Also, within each unit the serial learning curve is present. It is possible that, by placing the unique word in locations other than the middle of the sentence, we can take advantage of superior recall due to the primacy and recency effects that occur naturally at the beginnings and ends of sentences.

Studies utilizing CBI with young children have demonstrated that the principle of redundancy, as demonstrated by the drill-and-practice method, aids learning. Patrick Suppes (1974) has been the pioneer in this areas of research. He contends that retarded and nonretarded children, while they do not differ much in arithmetic computations, do differ on arithmetic reading tests, abstraction and the use of verbal information. There is a plethora of studies in the literature on mental retardation indicating that the mentally retarded are deficient in verbal learning. Our purpose is to determine whether verbal learning can be enhanced in the mentally retarded in a CBI setting using an established learning phenomenon.

It is our belief that, whether or not we succeed in these instances, meaningful progress in teaching individuals (retarded or otherwise) will be made only when the methods used are based upon established principles of learning. The CBI environment is ideal for the demonstration of learning. The flexibility of programming from a keyboard, the presentation of stimulus materials on a CRT and the possibilities for automated data collection dramatically reduce the time and effort required to perform experiments and make available new, refined measures to the experimenter. The advent of the microcomputer as a relatively inexpensive system should enhance the wedding between computer technology and cognitive psychology for which Kearsley (1977) has stressed a need.

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Abstract

Media Development Project for the Hearing Impaired
Videodisc Project

The past two decades have seen more change in the education of the deaf than the previous 100 years. Educational technology has contributed greatly to this change and is making significant contributions, but there is still a long way to go in the transfer of knowledge to handicapped children. The Media Development Project for the Hearing Impaired at the University of Nebraska-Lincoln is involved with a major national investigation and demonstration to probe applications of the new videodisc technology to learning for the hearing impaired. Also involved in this effort are Captioned Films and Telecommunications Branch of the Department of Health, Education and Welfare's Bureau of Education for the Handicapped, Corporation for Public Broadcasting, MCA Disco-Vision, Inc., Public Television Station KUON-TV, and the Great Plains National Instructional Television Library. The new videodisc technology has great promise for the hearing impaired, especially when it is combined with Line 21 captioning.

The MCA Disco-Vision disc, with which MDPHI is working, is twelve inches in diameter and has the capacity of 30 minutes of playing time on each side. In addition, the MCA videodisc can store a maximum of 54,000 single frames of information either as print or pictures with random access to each single frame. The disc itself is plastic, with the encoded portion beneath a highly polished metalized surface. It is read optically by a one milowatt neolaser; thus there is no physical contact during the reading process. The thousandth play will be as good as the first. The industrial videodisc player consists of an electronics unit, a turntable and a remote unit which controls all of the logic functions of the system. An additional capability of the MCA videodisc system is that it can possibly be interfaced with an intelligent terminal and computer.

The Project's first objective of having a Disco-Vision demonstration with Line 21 captioning at the 1978 Symposium on Research and Utilization of Educational Media for Teaching the Deaf was achieved last March. Following that demonstration the agencies involved began to gear up for the current phase of the Project which will develop four videodisc sides to demonstrate the unique characteristics of Disco-Vision and the contributions that this particular hardware can make to the education of the deaf. It is assumed that this effort will involve both extant productions and original programming which will exploit the interactive capabilities of videodisc technology, as well as Line 21 captioning. Specific strategies will be developed to exploit the freeze-frame, slow motion, electronic address, and fast random access capabilities of the hardware. Plans include the development of programs in the cognitive, affective and psychomotor domains at the various developmental levels of hearing impaired students, and strategies of independent learning, inquiry development, student-machine interaction, home environment utilization and others will need to be explored.

In addition to this demonstration activity, the development of a production process model will be a parallel outcome. As instructional design and production progress, the requisite expertise needed to apply this new technology to the learning needs of the deaf will be developed and shared with other facilities with TV production capabilities in order to assist them in adjusting their techniques to the videodisc format. Funds are available to encourage involvement from Kendall Demonstration Elementary School, The Model Secondary School for the Deaf and other educational programs for the deaf in the design of videodisc materials. Information developed in the production process and developing training models will also be disseminated to agencies and people dealing with handicapping conditions other than deafness.

A principal outcome of the Project will be to demonstrate the potential of Disco-Vision as an interactive delivery system for the knowledge and skills needed by handicapped learners to enable them to cope with an increasingly complex world. It will bring into reality computer-assisted instruction with unlimited visual display -- an exciting possiblity.

At this time the Project is still in its infancy and outcomes may vary from what is anticipated as work progresses, but developments to date will be discussed at the February ADCIS Conference. It is hoped that a demonstration disc will be available for presentation at that time, and full progress of the Project will be articulated.

PLATO COMPUTER-ASSISTED INSTRUCTION

APPLICATIONS IN SPECIAL EDUCATION

Robert M. Yeager
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1. Introduction

A. Project Participants

One of the PLATO Computer-Assisted Instruction (CAI) Projects in the area of Special Education which was sponsored by the Education Company of Control Data Corporation (CDC) in 1978, was a cooperative development effort involving Control Data and the Colorado Hearing and Speech Center in Denver. Control Data provided the necessary funding and special equipment and coordinated the project; the Colorado Hearing and Speech Center (CHSC) contributed the subject matter expertise of its speech pathologists and therapists; and Schaefges Traynor Consulting (STC) of Champaign, Illinois, and their staff, with whom we subcontracted, provided the design and programming talent required to complete the envisioned special education courseware base.

B. Project Rationale

The Control Data Education Company's Academic Education Division decided to instigate this development project because we wanted to produce and test courseware in Special Education areas, where the need for individualized and motivational materials is the greatest, and where PLATO could be immediately cost-effective.

There are over 5 million handicapped children in the United States. Of this number, according to figures released by the Department of Education in 1978, 21.5 percent suffer from learning disabilities, 35.2 percent have speech defects, and 2.4 percent are hearing-impaired. There is a potential obligation here involving at least 3 million children. The need for this type of remediation in centers like CHSC, and in public and private schools across the nation, is tremendous.

The Colorado Hearing and Speech Center's dilemma was the $30-an-hour cost for one therapist to work with one child, in primarily just a drill-and-practice mode, week after week. The Center felt that potentially more effective drill-and-practice exercises could be delivered via PLATO at a cost far below their estimated hourly rate. All that was needed was at least an initial body of appropriate courseware.

C. Student Population

The students for whom the lessons in this project were created were children in kindergarten through third grade who were learning-disabled. Some children had additional speech and hearing impairments. All had perceptual problems in the visual and auditory processing areas.

II. Project Description: Courseware Development, Project Implementation, and Evaluation

A. Courseware Development

The development portion of the project extended from December 15, 1977, through March 1, 1978. Seventeen drill-and-practice lessons in visual memory skills (the area of greatest need, as identified by the CHSC therapists), and containing an average of 28 hours of unique instruction, were completed.

The lessons developed not only concentrate on the one area the CHSC therapists identified as being the most troublesome for their children, but this skill also represents an area which lends itself easily to computerized drill-and-practice. Thus, one of the goals of these lessons was to relieve the therapists at CHSC of tedious practice sessions with clients. At the same time, the children would receive more intensive practice in that skill area at the PLATO terminal than therapists could normally afford to give them. The computer could deliver more practice at less cost than a therapist, and the therapists could devote more time to work on more complex skills with their children. One of the objectives of this project was, therefore, to provide for the CHSC therapists a full battery of varied drill-and-practice lessons which they could use to bring a student to mastery in the skill area of visual memory -- to provide a set of "tools" which skilled therapists and teachers could use to bring about measurable improvement in specific skill areas.

The lessons were designed to be controlled by the therapist or the teacher. In other words, these lessons are managed by people, not by the computer. The therapists at CHSC and elsewhere deal with very sensitive problems. Young children do not follow an orderly progression in skill development. The current state-of-the-art in computer-based education is such that even the biggest and most sophisticated computer programs cannot be made sensitive enough to entirely keep up with the sporadic development of a young child. Recognizing this fact, these lessons put the decision-making where it belongs: in the hands of the skilled therapist.

At the general level, therapists could select and sequence the lessons each student was to receive. The computer provided data to the therapists to help them make their decisions, but it was the therapists, not the computer, who made the final selection of lessons for each student.

At the lesson level, therapists could custom-tailor each lesson to the needs of each student. For example, some students do better if they have more positive reinforcement. These lessons allowed the therapists to set the levels of reinforcement for each student.

B. Equipment

The drill-and-practice lessons in visual memory designed for this project and, it is hoped, eventually for widespread distribution to special education sites, take advantage of the most modern technology available. Some of the equipment described below was specifically obtained for the CHSC project because of the unique nature of the students for whom the lessons are designed. Older and more sophisticated students can be expected to come to the PLATO terminal with a high degree of self-motivation. However, the students for whom these lessons were developed have to be motivated by the lessons themselves, and, since much of the available technology was too slow or unresponsive to the needs of these children, Control Data supplied the project with some of the latest hardware available.

1. The PLATO Information System (IST) Terminal

a. The PLATO "Information System Terminal" (IST) has a cathoderay tube (CRT) screen which looks like a television screen. There are two distinct advantages to using the IST terminal:

- the IST terminal can write in bold-face letters which are twice as large as conventional lettering, and the bold face letters are written as fast as standard-size type.
- The IST terminal can erase faster than PLATO IV PLASMA terminals.

b. All of the lessons take advantage of those two features. The lessons were also written so that they could be viewed on a PLATO IV terminal. However, when the lessons are used on a PLATO IV terminal, the lettering is done in thinner, line-drawn letters, which plot relatively slowly on the screen. In addition, the erasing is extremely slow, and appears to cause unnatural delays in the lesson. Therefore, although it is possible to see the lessons via a PLATO IV terminal, it is not advisable to have actual students use any of the lessons unless they have an IST.

c. The bold-face lettering and the fast erasing are just two examples of why the CHSC lessons require the most modern technology. The PLATO IV terminal represents an extremely sophisticated and advanced technology; nevertheless, it could not meet the needs of all the instructional strategies planned for this project. Some lessons could have been written which stayed within the limitations of the PLATO IV technology, but the decision was made to support the full range of instructional strategies with whatever technology was needed.

For this project, then, the instructional requirements determined the type of technology used, rather than vice versa.

d. The "Intelligent" Terminal

1. An IST can have a small computer built into it. These "intelligent terminals" (terminals with micro-computers built into them) are not, as yet, commonly used on the PLATO system, but they are in development, and should be widely available in the near future.

2. "Intelligent terminals" are capable of producing better graphics, and of being more responsive to the student. They can do that because all of the computing that is necessary to create a display can be done with the micro-computer inside each terminal, rather than on the large Control Data CYBER computer to which all PLATO terminals are attached. There are two limitations when using the large CYBER computer to deliver graphics:

- because the CYBER must service hundreds of users at the same time, it can only provide a limited amount of computer time to each terminal. Animations are typically very simple computer programs, but they may absorb vast amounts of computer time because they require the same simple operation ("move the box one dot to the right") hundreds of times.

- The phone line connecting the Control Data CYBER computer to the terminal can only carry limited amounts of data to the terminal. For example, the picture of the balloon clown in the CHSC lessons takes 7.5 seconds to draw on the PLATO IV screen only because it takes that long to send the picture through the phone lines. With the intelligent terminal, the clown can be drawn in less than one second.

3. Intelligent terminals can also be more responsive to the students, for the same types of reasons. For example, the CHSC "Loading Dock" lesson features a box which moves across a conveyor belt. The students can touch the box at any time in order to "load" the box on the truck. The intelligent terminal recognizes the student's touch instantly. A PLATO IV terminal will take several seconds to process that touch because the Control Data CYBER computer has to both animate the box and be responsive to a touch at the same time, and the phone lines become clogged with data going back and forth. There is no way to reliably complete this type of interaction with a PLATO IV terminal.

4. Such high-powered graphics, combined with the ability to allow the students to interrupt animations instantly, were felt to be necessary to hold the students' interest in the lessons. Young students will simply "tune out" after a while, if the lessons move too slowly for them.

5. Finally, the intelligent terminal makes it possible to use sophisticated visual cues to draw the student's attention to the desired area of the screen. These seventeen lessons have just begun to explore that potential. Future lesson development is expected to take full advantage of these capabilities.

e. The Touch Panel

Control Data IST PLATO terminals come equipped with a pressure-sensitive "touch panel". This allows the students to respond to the computer by simply touching the screen with their finger. Students do not have to learn how to type to use these lessons; the only key on the keyboard which they are ever asked to press is the NEXT key, and even very young children have learned to do that quickly, once they have been shown how to do it.

2. The Audio Response Unit

a. The lessons, as originally designed, rely upon an Audio Response Unit available from Education and Information Services (EIS) of Champaign, Illinois. Twelve "records" were used for the lessons. A "record" is approximately thirteen inches in diameter, and is made of flexible mylar tape (the same type of tape that tape recorders use, except that it has been cut in a large circle instead of a long ribbon). Students were told whenever they were to switch to another record, and they generally were able to change the records with little difficulty, since the EIS unit works exactly like a toaster on its side.

b. Each record can hold up to twenty minutes of recorded audio. The EIS system provides for the use of real human voices, and captures all the intonations possible in a real voice. These lessons used both male and female voices.

c. The EIS "RA-4096" unit can play any audio message on a record within two-thirds of a second, so that the audio unit responds "instantly" as far as the student is concerned. Because the EIS unit can, in theory, play any message at any place on the record, sophisticated instructional strategies were developed. For example, in "The Ticket Agent" wrong answers were reviewed on a regular schedule. Such a strategy is only possible if the audio unit is capable of instantly playing any message at any time.

d. The lessons were also equipped with "simulated" audio, whereby the audio messages were written at the top of the screen. Simulated audio was never used with the actual students, however. The simulated audio exists so that people who do not have an EIS audio response unit, or who do not have the twelve records needed for these lessons, can review the lessons.

3. The Tektronix Copier

a. A copier made by Tektronix, Inc. was used to make paper copies of screen displays. The lessons were designed so that the students ended each lesson with a full-screen display that illustrated all the items that were in that lesson, along with their score. Students could make a copy of each display to show their teachers and their parents. These paper copies helped the therapists at CHSC and the parents stay in touch with what the students were doing on the PLATO terminal, and the copies could be used by the students to keep track of their progress.

b. The Tektronix copier also allowed the therapists to copy data for each student. The therapists were able to "call up" summary data for any student on the screen, and the Tektronix copier allowed them to make quick paper copies of that data for later reference. Even though each student's data was saved within the computer and could be retrieved quickly at any time, the teachers still liked to have paper copies on which to make notes.

C. Evaluation Of The Project Lessons

The lesson evaluation was conducted by The Colorado Hearing and Speech Center's staff from April 1, 1978, through July 31, 1978. The objectives to be addressed by the evaluation, as defined by the therapists at CHSC, were as follows:

- to evaluate the various technical aspects of PLATO -- hardware and software
- to evaluate the effect of PLATO on the child's progress
- to provide information for additional and continuing development and use of PLATO with children with learning disabilities.

Thirteen children were selected to participate in the pilot, twelve of whom completed the evaluation. The children, all with visual and/or auditory processing problems, were scheduled for two one-half hour sessons per week on PLATO. The total participation amounted to 205 sessions, or 102 hours of time on PLATO, using the visual memory lessons.

In addition, four children with special needs were observed for several sessions, in order to gain some information regarding their ability to interact with PLATO. Two of the children were hearing-impaired, one was moderately mentally retarded, and one child was mildly cerebral palsied.

Various tests selected by the therapists for use with individual children for pre and post-test measurement included the I.T.P.A., visual sequential and auditory memory sections, and applicable sections from the Detroit, the Slingerland, and the Wide Range Achievement tests.

1. Positive Results

The CHSC therapists concluded that PLATO and the specific lessons in visual memory produced an overall increase in both visual and auditory memory skills, which was reflected in the post-test scores. The therapists also noted an improvement in the children's learning strategies and in the manner in which they approached memory tasks. Children showed an increased ability, for example, to utilize such strategies as re-auditorization and rehearsal, and mnemonic devices, as well as becoming more aware of their own memory span.

In addition, the CHSC staff reported that PLATO proved to be a most beneficial alternative method for presenting memory tasks. The animation and reinforcement capabilities of the lessons and the system were motivational and appealing. The therapists were also very positive about their ability to individualize each student's lesson and session on PLATO, through the use of the parameters in the prescribing portion of the lessons.

2. Problem Areas

The major problem encountered during the pilot and evaluation of our PLATO materials was with the unreliability of the EIS device used to deliver the audio portion of the lessons. Although the percentage of faulty audio messages may have actually been as low as 5 percent, even this error rate was untenable, given the nature of the lessons being delivered, and the children who were receiving the instruction.

A second problem lay in the fact that the base of materials developed for this project was simply too small for the number of lessons required to meet the Colorado Hearing and Speech Center's goal of independently-delivered, cost-effective PLATO-based instruction.

We intend to attack both problem areas in our current, new development effort.

D. Future Plans

Based on the encouraging outcome of the evaluation of PLATO and of the base of specially designed lessons at the Colorado Hearing and Speech Center last year, the Control Data Education Company has decided to continue this Special Education courseware development effort. We have again contracted with Schaefges and Traynor Consulting to design and program 45 additional drill-and-practice lessons for kindergarten through third graders who have learning problems. The lessons developed for the first pilot at CHSC will be revamped so that they will be audio-independent. Additional visual reinforcement will displace the audio feedback. We will be working with a noted educator of the deaf in order to enable us to produce lessons that will be of use to deaf children as well.

The initial 17 lessons in visual memory skills, now redesigned to be audio-independent, plus the estimated 45 new drill-and-practice lessons, also audio-independent, will be tested at both the Colorado Hearing and Speech Center and at the Kendall Elementary School For The Deaf in Washington, D.C. from April through July of 1979.

The instructional design considerations we attempted to utilize in our first development effort, and which will continue to be the focal point for the 45-lesson courseware design and development project which will be implemented in April, are discussed in more detail in the following section.

III. Lesson Design In The Project

Students in the target populations are typically confused by the variety of external stimuli which constantly besiege them. A computer terminal can become just one more added stimulus which may bring confusion into their world. The goal of good instructional design for computer-based lessons must be to minimize this confusion. This can be done in two general ways: (1)by establishing a continuity across all lessons; and (2)by integrating the experience at the computer terminal with the other educational experiences in which the students are involved.

The most important consideration in designing lessons for young children and for children with learning disabilities is to establish a continuity across all lessons. Each lesson must work in a predictable way--that is, students must be cued for responses in similar ways; the computer terminal must use familiar formats to indicate that it has accepted the student's response; and correct and incorrect feedback must be distinguishable and concrete.

Recognizing this need for continuity produces good results for both students and for lesson designers. As suggested above, students benefit from learning to operate effectively in a stable environment. In addition to developing reading readiness skills, students also have a chance to gain confidence in their own effectiveness. The computer terminal becomes a small world which they can manipulate and in which they can experience success. Their time at the computer terminal becomes a refuge where they learn to sort out the competing stimuli, and where their ability to focus their attention has an immediate and positive reward--they learn that they can be effective within that environment.

We have consistently observed students with learning disabilities train themselves to focus their attention while working at a computer terminal. But, in the past, they have often again become distracted as soon as they have left the terminal.

For the lesson designer, the advantage of building a continuity across lessons lies in the ability to refine a few basic instructional pardigms which can be used to spawn many lessons. Lessons in this mode can be produced more economically (in terms of human resources) than would be the case if each lesson were developed independently, and the savings in resources can be applied to improving the paradigms.

Although many lessons may be built from a single paradigm, such lessons are not necessarily repetitive to the students. The "paradigm" describes the instructional strategies employed in the lessons; it defines such things as the expected types of student interactions, and how right and wrong answers should be handled. But several lessons can be built on the same paradigm by creating different imaginary environments. For example, both the "Balloon Clown" lessons and the "Memory Train" lesson are based on the same paradigm--the students make the same types of responses, and the error analysis in both lessons is identical. In one lesson, however, the students fill up balloons and then are allowed to "break" them, and in the other, they load a train and get a puff of smoke if they have done the lesson correctly. Although the lessons are based on the same paradigm, students do not perceive the lessons to be the same.

On the other hand, the same imaginary environments might be used with different paradigms. For example, we could use the "Memory Train" setting in a "letter names" paradigm. In that case, students typically remember that they have seen that lesson before, even though they are practicing a different skill.

The underlying instructional paradigms give the students the needed continuity. The different environments built from a paradigm offer the students the needed variety.

As suggested above, even though previous computer-based lessons have achieved the desired effects on the students while they were at the computer terminal, it has often been difficult to transfer that gain into the rest of their environment. The new series of lessons will directly attack that problem. In the past, most computer-based lessons have been designed to operate independently of a teacher. This series of lessons will require the participation of the teacher at critical points. The teacher, for example, must spend approximately thirty minutes to introduce the students to each new category of lessons as the student encounters them. All of the lessons presume that the teacher has done the primary instruction--the computer terminal only offers the student a chance to practice the skills.

Once the teacher has completed the orientation, the students should be able to operate the computer terminal independently for several hours of instruction. The teacher will have to be present for ten to twenty percent (depending on the child) of the time the student is at the terminal.

The assumption of the above procedure is that the teacher's presence will reinforce the bond between instruction on the computer terminal and instruction with the teacher. We have also concluded that it is far more economical and effective to have the teacher demonstrate how to operate the lessons than to try to build that type of explanation into a computer-based lesson.

The computer terminal becomes a valuable educational tool in the hands of a skilled teacher. A teacher will use that tool to augment the amount of practice a student receives in a given area. They will select the computer-based lessons as another way of achieving that practice, and will, at the same time, achieve some of the goals described above, such as developing self confidence and focusing attention.

To maximize the teacher's ability to use the computer terminal as a tool, a wide variety of management programs have been developed. The teachers can use existing sequences of instruction which have been arranged by the curriculum developers; they can modify existing sequences for individual students; or, dedicated teachers can design all or part of their own sequences.

The management options allow teachers to specify lessons for a session; to specify criteria for branching from one lesson to the next; to set criteria for completing a lesson; and even to set the items to use in that lesson and the sequence in which the items will be presented. With the exception of the instructional strategies specified by a particular paradigm, the teachers can exert total control over the way a lesson operates.

Thus, this series of lessons can be used by a variety of students. All of the instructional paradigms are aimed at young students and/or students with learning disabilities, since older students without learning disabilities would be bored with the slow pace and repetitiveness of the lessons. The lessons recognize the vast range of differences among students in the target populations, and seek to allow the teacher to use the computer terminal as part of the regular instruction.

1 December 1978

Geoff Zawolkow
School for the Deaf

COMPUTER EDUCATION FOR THE DEAF in the SAN FRANCISCO BAY AREA

Computer aided instruction (CAI) has been a regular part of the program at the California School for the Deaf (CSDB) since 1970. At that time, Stanford University with a grant from HEW did a research project using students at the School. The encouraging results showed that CAI was beneficial to deaf students (Suppes, 1973).

After the Stanford Study terminated in 1973, the CSDB administration started looking for a way to continue providing CAI to the students. The Lawrence Hall of Science (L.H.S.) of the University of California, Berkeley, was contacted. They agreed to provide a time-share system and software support for this effort. Funds were provided by the ESEA Title I grant, and has continued since.

The Title I CAI program depends on timesharing with a nova-eclipse mini-computer located at the L.H.S. about three miles from the school. There is a central computer resource center at the school, having 12 hard copy computer terminals (KSR 33 TTY's) connected via three telephone lines to the computer. A proctor is responsible for the supervision of the room. Her responsibilities include: setting up schedules, typing in lessons for teachers, helping students become familiar with the computer, and aiding teachers with lesson development. She also arranges for machine and telephone line maintenance.

Essential to the program is the capability of providing programming assistance to the faculty at the school. As a result, teachers are freed from using "canned" software, and given the "power" to individualize computer materials so as to meet the unique needs of their students.

The programs available to faculty and students include 12 author programs for lesson development, as well as an extensive library of math programs, simulations, games and language programs. The teachers have authored some 1,500 lessons. As it is, the project has several limitations:

1) Due to the high cost of timeshare, telephone tie-in, and maintenance; dissemination of developed materials has not been practical.

2) Due to it's textual format limitations, the present machines do not allow access to low functioning students.

3) A great deal of class time is used going from remote classrooms to the computer lab.

In order to solve these problems, the CSDB was awarded a Title IV-C grant in November of 1978. The project has two major thrusts:

1) Establishment of CSDB as a regional center for cooperative development and dissemination of CAI programs, and

2) A micro-computer graphics system (Apple-II). It provides the following benefits: color graphic displays, portability, reliability, low costs and a network for dissemination.

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DEVELOPING AN ELEMENTARY SCHOOL PROBLEM SOLVING CURRICULUM IN CAI

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Solving story problems has long been a hated and feared task for both mathematics students and teachers. In this paper, I shall describe the development of a problem solving course that is aimed at eliminating some of the fear and dread. Problem Solving (Noddings, 1978) is an elementary school (grades 3-6) mathematics curriculum designed for use in Computer Assisted Instruction. Discussion will be organized around four stages in the development of the curriculum.

Stage One: The Problem with Problem Solving

Why do students have so much difficulty with word problems? The problem with word problems, some educators suggest, is reading: solve the "reading problem," and the problem with story problems will disappear (Alexander, 1960; Martin, 1963). This contention, plausible as it seems, is not strongly supported by the evidence at hand. Investigators have shown that many children with normal scores in reading still experience difficulty in solving story problems (Balow, 1964; Knifong and Holtan, 1976, 1977). Indeed, students who can read problems accurately aloud often do not know how to proceed. Hence, while it is true that youngsters who have obvious difficulty in reading will experience derived difficulty in problem solving, it is clear that other difficulties must be involved also.

In a series of studies (Loftus, 1970; Loftus and Suppes, 1972; Searle, Lorton, and Suppes, 1974), it has been suggested that structural difficulties in the problems themselves account for some student difficulties. Problems which require a large number of operations or conversion of units will be difficult; problem statements which exhibit complex surface structures or many words will be difficult; problems which differ from preceding problems will be more difficult than those which are similar to their predecessors.

Clerical and computational errors account for some of the faulty performance in problem solving (Knifong and Holtan, 1976). Further, procedural errors (Kantowski, 1977; Knifong and Holtan, 1976; Polya, 1945) loom large in the analysis of difficulty. Students often do not know how to begin, where to focus their attention, or how to monitor their own progress toward a solution.

Finally, motivational and affective factors, (Holt, 1964; Polya, 1945) enter the picture. When students lack confidence in their mathematical abilities, they often turn to nonmathematical heuristics in their attempts to solve problems. They make guesses and judge by their teachers' frowns or smiles how good the guesses are!

With these five areas of potential difficulty in mind, we could begin to describe the curriculum we wanted in rather holistic terms. We could even make some decisions on specific organizational matters. We decided, for example, that our problems would be presented at two or three levels of structural difficulty. The first level would use a minimum of words and state all problems simply. Higher levels would use more words and complex sentence structures. It would be possible for students to complete the entire course conceptually at the basic level. We decided also that, given mixed evidence on the "reading problem" and given that many of our users had demonstrated reading problems, our curriculum should employ a redundant vocabulary. Our idea was to keep the nonmathematical skills and peripheral information required to a minimum. But, of course, there is some risk of boredom in designing story problems with a redundant vocabulary. It was decided, therefore, to introduce some variety into the noun class where research indicates it causes little difficulty (Blankenship and Lovitt, 1976).

Procedural and affective factors concerned us greatly. CAI has obvious potential for reducing anxiety and fear. The computer does not frown, or threaten, or become exasperated with its students. We wanted to maximize this strength. Most CAI lessons end with a report informing the student how many correct and incorrect responses have been made on the day's lesson. It was decided to add to our lesson report a category "correct with help" so that a student who followed our pedagogical hints could achieve a sense of success from having done so. Assessment of this report also tells the teacher whether a particular student is profiting from the computer's instruction or whether he/she might need special encouragement from the teacher.

To cope with procedural difficulties, the curriculum was to incorporate general heuristics of problem solving and special techniques for specific problem types. This initial decision was to lead eventually to an "Alpha, Beta, Gamma" structure in our presentations. This structure, which I will describe later, would emphasize general problem solving heuristics at the first stage in both Beta and Gamma and specific techniques at the second stage in those sections.

Ideas for reducing clerical and computational errors arose gradually. As we began writing our problems and sought the best form for each type, we saw that the computer could be used as a model of neat and accurate computational form. Sometimes, then we would require students to perform digit by digit computation on the computer screen; other times, we would request an answer only, and this format would require students to perform their own pencil and paper computation before responding. We hoped, of course, that this continual modeling would contribute to a reduction in computational and clerical errors.

We were committed early, then, to a multi-level curriculum organized by structural difficulty; to an attempt to teach general and specific problem solving techniques and not to the mere presentation of problems; and to a continuing effort to encourage students in their efforts and to reduce their anxieties about story problems.

Stage Two: Basic Organization

How should the curriculum be organized? A survey of popular texts shows that story problems appear at fairly regular intervals throughout the texts and that they are organized around activity themes, e.g. "Grandmother's Farm," "A Halloween Party." This thematic organization is not very helpful in creating sequential schemes and, indeed, one finds actual repetition of problems across grade levels.

Problem Solving is organized as a "strands" curriculum. The strands are built on topics which form the central core of work on story problems appearing in widely used texts and standardized tests. If one digs below the thematic organization mentioned above, one finds characteristic *mathematical* questions and themes. The strands are named in just the way students and teachers usually talk about the topics:

A. How many
B. Money
C. Mystery number and age
D. Measure
E. Number system
F. Time, rate, and distance
G. Geometry

Classification of problems in current texts can be made by analyzing 1) the question asked and 2) whether or not the mathematical topic being considered is *essential* in the problem. Consider the problem: "John drank 2 pints of milk Tuesday and 3 pints of milk on Wednesday. How many pints did he drink altogether?" Should this problem be classified as "How many" or as "Measure"? It was decided that the measure, "pints," does not enter the problem in an essential way; that is, the reader does not need to know the meaning of "pint" in order to solve the problem. Therefore, the problem was classified as "How many." Using this sort of analysis, it was possible to survey popular texts and count the number of problems in each category. *Problem Solving* offers a representative distribution.

The next important question is how to present the problems to students. Lessons could be organized in blocks of problems from a single strand. This approach has obvious advantages. One can present the topic in textbook fashion, give examples, monitor practice. But there are disadvantages also. In the analysis of structural difficulties, it was pointed out that students find it relatively easy to do a particular problem if it is just like its predecessor. This kind of success does not seem to represent anything signficant in mathematics learning. Further, presentation in blocks seems to encourage specific techniques rather than the general heuristics we wanted to teach.

It was decided to present a mixture of problems from each active strand according to the distribution established by our survey. It was also decided, however, that whenever students got a problem wrong, they would immediately see another problem just like it. Should this happen three times in a row, mixed presentation would be automatically reactivated. The capability of producing a host of problems just like a given problem is a unique strength of computerized presentation. Since each problem is generated from a "generic form," many different problems of exactly the same form are immediately available. Further, it is most unlikely that any student will see exactly the same problem twice.

The decision to use topical strands in the curriculum organization helped greatly in the large task of sequencing problems. We could work through an entire strand from its initial activation to the end of sixth grade. Further, as the basic strands were completed, we could begin interweaving them with later strands. Thus, a "Time, rate, and distance" problem might involve subtasks that had been presented in the strands on "Money" and "Measure."

As I am describing it, the task of curriculum creation seems to be linear. It is not, of course. Right from the start, we were engaged in writing sample problems, and difficulties that arose in that task influenced the overall planning of curriculum. We worked as a team -- writer, editor, and programmer -- from the start, and this arrangement also influenced our planning. Problems which were not well suited to computer presentation -- odd, one-of-a-kind problems -- were cast out. Problems which required graphics beyond our capability were eliminated or restructured. The early stages were characterized by idea generation, argument, trying-out, and attempts to understand and appreciate the tasks of each curriculum worker. Later work, as a result of team decision making, was streamlined.

Stage Three: The Tutorial Component

CAI programs often aim to provide practice and reinforcement. Programs that actually attempt to teach problem solving skills are relatively rare. *The Word Problem Program* of Roman and Laudato (1974) is an important example in the teaching category; it concentrates on teaching the translation of word problems into number sentences. Students are taught how to set up problems, and the computer handles the necessary computations. Clearly, an underlying assumption of this program is that the translation stage of problem solving is crucial and that it is dominantly analytic.

Problem Solving takes a different approach. First we postulate a holistic stage in problem solving--one in which the problem is grasped intuitively. At this stage students may visualize the problematic situation. Indeed, it is entirely possible that youngsters in third and fourth grades can solve certain simple word problems without being conscious of the arithmetic operations they use in their solutions. The analytic mode so characteristic of later mathematical thinking may not be natural for young children. We decided to approach it gradually.

Second, we wanted to discourage the use of nonmathematical heuristics and algorithms in problem solving. Roman and Laudato, with the same aim, employed three techniques in their program: (1) writing problems so that cue words and phrases, i.e. "each," divided by," were missing; (2) sequencing problems so that no two consecutive problems were alike; (3) varying the numbers so that the numbers themselves would not provide a clue to the required operation. *Problem Solving* uses the second (sequencing) technique, ignores the third, and rejects the first. In fact, a deliberate effort is made to teach children who cannot grasp the general heuristics ways in which to make use of cue expressions. We felt this technique could be important in itself, but, also, we wanted our problems to look like those children would encounter in texts and tests.

Because what goes on in the postulated holistic stage of problem solving is not well understood, it was decided to start with problems that could be solved mentally. In third and fourth grades, then, the Alpha stage of instruction simply presents a problem and requests an answer:

Alpha Stage

> Jane has 12 stamps, Kathy has 5. Jane has how many more stamps than Kathy?

Students are not asked to identify an operation at this stage, because we do not want to interfere with whatever intuitive processes may be going on. Premature concentration on the formal aspects of problem solving may lead to the sort of wild guessing and mathematical stupidity so well described by John Holt (1964).

If the student answers correctly, however, the program moves to the Beta Stage:

> Good. You got it! Which number sentence tells you how you got your answer?
>
> a. 12 - 5 = 7
> b. 12 - 5 - 6
> c. 12 + 5 - 17
> d. 13 - 6 - 7

With the reinforcement of success at the Alpha Stage, students may be ready to reflect on what they did, and how it might be described formally. If the student responds incorrectly in Beta, a hint is given:

> Think again about the numbers you used to get the answer:
>
> ( ) - ( ) = 7
>
> The student is then invited to "try again."

Throughout the Beta Stage, we try to induce "looking back," a heuristic long endorsed by mathematics educators (Polya, 1945; Kantowski, 1977). Through this two part process -- intuitive solution and reflection on formal aspects -- we hope to provide a natural transition from intuitive to analytic process.

Students who answer incorrectly in Alpha are aided in the Gamma Stage:

> Let me help you. The problem asks you to find:

a. how many stamps Kathy has
b. how many more stamps Jane has than Kathy
c. how many stamps Jane has.

Students who answer again incorrectly are advised:

> Read the problem again. Read the QUESTION carefully.

They are then invited to "try again." This technique -- read and reread -- is another general heuristic strongly recommended by mathematics educators (Earp, 1970; Blankenship and Lovitt, 1976).

In grades five and six, the order of response in Alpha and Beta is reversed. Students are now asked in Alpha to "choose an expression which tells how to find out" and in Beta to carry out the required computation. Students at this stage can handle computations which cannot be carried out mentally.

Problem Solving always requires students to complete solutions. In a later section, I shall describe the ways in which actual solutions are carried out. Here I want to emphasize that "carrying out" is seen as an important part of the holistic view of Problem Solving. We want students to reflect continually on the relations between means and ends. To do this thoughtfully they must live the consequences of their decisions at each stage of solution and then look back on these decisions and the results thus obtained.

Stage Four: Modes of Response

The final stage in planning for Problem Solving involved a consideration of modes of presentation and modes of response. Initially, we rejected a proposal that would have had the computer do all the calculations, but we realized that students could profit from instruction in using the computer as a calculator. We also wanted students to have experience with test-like situations in which they would have to perform calculations aside and respond by choosing the correct answer from a multiple choice array. So there were two experiential objectives that influenced our thinking about response modes. As a result, some problems in "Test Mode" are presented at every grade level and in every strand; problems in "Calculator Mode" begin, after instruction in use of the computer as calculator, at the fifth grade.

As problem writing progressed, it became clear that two other modes might be very valuable. I mentioned earlier that computations could be set up on the terminal screens so that students could perform computations as they would with pencil and paper. Computations performed this way are always neatly and properly set up, and the computer performs a digit-by-digit check on computational accuracy. With Computational Mode, students do their own calculations, but the computer provides a model of clerical excellence. It is hoped, of course, that Computational Mode and Test Mode will work together toward a reduction of computational and clerical errors.

Although word problems in general are difficult for many students, some types are more difficult than others. "Measure" problems, for example, seem to be especially difficult (Knifong and Holtan, 1976). Some of the difficulty with measure may be traced to faulty or missing information. It was decided, therefore, to supply a "pre-problem context" for measure problems. In D 4.21, for example, students are asked:

> Which is greater, 22 hours or 1 day?

If an error is made, they are told (in Gamma):

> There are 24 hours in a day. Which is bigger 22 or 24?

We also introduced a Structural Mode to provide models of mathematical reasoning. In a textbook, sample problems of this sort might or might not be actually read by the student. In Problem Solving, students must read the model problem, because they are required to respond by filling in blanks. Consider, for example, D 5.21:

> Jane buys a gallon of punch for a party.
> She drinks 1 quart before the party.
> How many quarts are left?

Fill in the blanks:

1 gallon = 4 quarts
amount Jane drinks = 1 qt.
amount left = 3 qt.

Structural Mode is also used to model the solution of equations: C 6.51

A certain number is multipled by 3.
Then 4 is subtracted from the product.

The result is 5. Can you find the number? Choose the expression which tells how to find it:

a. (3 x number) - 4 = 5
b. (number x 3) + 4 = 5
c. (4 x number) - 3 = 5

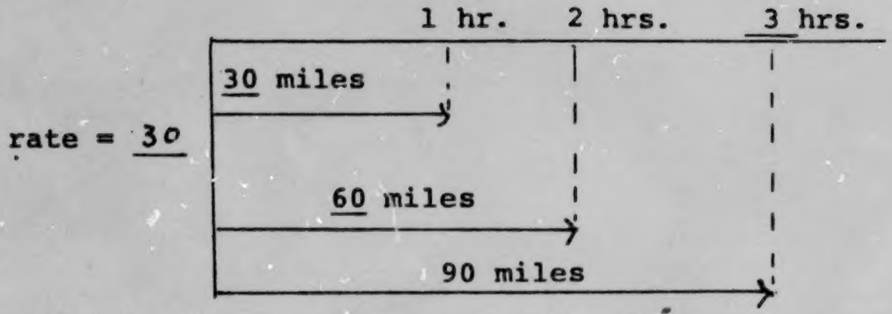
Students who answer correctly are moved to Beta:

(1) (3 x number) - 4 = 5
(2) 3 x number = 9
(3) number = 3

Structural Mode is used, again, to acquaint students with useful diagrams. In Strand F, "Time, rate and distance," instruction begins with diagrams:

F 5.11

A car travels at the rate of 30 miles per hour. Fill in the blanks in the picture below which shows how far the car goes in 1, 2, or 3 hours.



Summarizing the decisions on problem format, several modes of presentation and response were devised to accomplish the following: provide experience with test-like situations; provide familiarity with the computer as calculator; use the computer as a model of clerical and computational excellence; use the computer as a model of mathematical reasoning; use the computer to model diagrams; provide a pre-problem context in which to familiarize students with information on units of measure.

SUMMARY

Planning for Problem Solving evolved through four important stages. In Stage One, a theoretical framework was established; it was decided to view problem solving holistically. At this stage, research on problem solving difficulties was reviewed and assessed, and decisions were made to incorporate several special features in the curriculum: a redundant vocabulary, multi-level presentation to conform with what is known about structural difficulties, and an attempt to teach general heuristics of problem solving.

In Stage Two, problems of organization were studied. It was decided to use "topical strands" as the basic feature of organization, and to present students with a mixture of problems varying at every level according to an established distribution table.

In Stage Three, the tutorial component was created. A unique feature of Problem Solving is its gradually increasing emphasis on the formal or analytic aspects of problem solution. An Alpha, Beta, Gamma structure is used to permit instruction in both general heuristics and techniques specific to given problem types.

Finally, in Stage Four, modes of presentation and response were considered. To provide the breadth of experience that seemed both desirable and possible with CAI, four distinct modes were created: Computational, Test, Calculator, and Structural.

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Innovative Classroom Applications of Computer Technology

by

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Computing terminals are expected to become as frequent an item in today's household as the telephone, stereo, and refrigerator. In addition, individual life styles are also expected to adjust to the potential afforded by the integrated circuitry of the electronic age. The increasing popularity attributed to the efficiency and long-term economy of computing terminals (as a household planning tool) by today's consumer reflects the interest and willingness of individuals to adapt their present life styles to the time-saving device. Since almost every aspect of our daily lives is expected to be affected by the computer, it was decided to educate the youth of the State of Delaware coming through the public educational system as to the impact of computing upon life and work styles.

The emergence of integrated computing networks also provides the educational community with many alternatives for increasing the effectiveness of existing instructional systems. The capabilities of the computer as an instructional aid in testing, curriculum delivery, and program management enable the classroom instructor to implement teaching-learning systems to meet the individual needs of each student. It is now becoming economically feasible to incorporate computer technology into the classroom as opposed to supporting traditional instructional approaches.

I. Approach: Program Design for Computer Education

In Delaware, an experimental project has been undertaken to incorporate the computer into the classroom via a time-sharing network. Called Project DELTA (an acronym for Delaware's Total Approach to Computer Knowledge), the computer education program focuses upon how to use the computer as a problem-solving tool through the development of data-flow concepts, what one can do with data, and the consequences of error formatting. The DELTA program offers an alternative to computer-assisted instruction, administrative computer usage, and the traditional computer science function of preparing machine operators, programmers, and/or systems analysts. *It is the new user of computer technology who is the primary target of DELTA*.

The computer education project was initiated by the Delaware School Auxiliary Association, which is an organization interested in the implementation of computer education in every school in Delaware. Through a coordinated effort with the State Department of Public Instruction and the University of Delaware, the Delaware School Auxiliary Association generated a funded program whereby computing terminals are to be placed in public schools throughout the state. Using a time-sharing arrangement, computing terminals have been strategically located in secondary and post-secondary schools whose classroom teachers have willingly accepted the responsibility to implement computer education as part of an existing program. The thrust of the computer education program is to stimulate the learner--whether a classroom instructor or student--to become an effective user of the computer, and not a programmer or formal researcher. The instructional materials incorporated into the training program guide the learner on the assumption that he/she has had no background in computing. Instruction is geared towards the classroom teacher who has very limited amounts of time to establish new units of curriculum as well as students with similar time restraints for completing computing assignments.

II. *Method*: *Development of Software*

Although representatives from the business community, students majoring in business education, and classroom teachers associated with business programs in the secondary and post-secondary schools were used for identifying and refining the software developed in the DELTA program, the products resulting from the experimental project have applicability to those individuals in other programs. The software permits the new user to formulate questions in ordinary everyday language. The user may reference data by indicating descriptive terms rather than having to identify physical record locations. The software operates interactively so the student can input an inquiry in response to the results of a data base search. Inquiries may take the form of a single question or a series of questions. Data base manipulation allows the new user to generate reports and other documents.

The experiment included the establishment of a time-sharing network which permits secondary and post-secondary schools to use the PDP 11/70 central processing unit at the University of Delaware through formal contractual agreements. The project reflects an emphasis upon data base management whereby the software developed enables the user to create, edit, and manipulate files while solving basic informational problems. The computer education program consists of a series of exercises based on having users who are not data processing specialists handle the functions of establishing and searching data bases.

Upon field testing the instructional materials developed as part of the computer education program with 32 students and classroom teachers, seven individually prescribed learning modules were refined and produced as part of the DELTA time-sharing network. The instructional modules guide the new user through a sequential learning experience from discovering how to interact with a central processing unit via a video-display terminal to solving case studies simulating actual business practices (e.g., generating a payroll, customer billing, and inventory, etc.) Each module contains specific performance tasks, prescribed learning activities, and computer programs to be executed.

III. Results: Modular Instruction in Computer Education

The DELTA training program consists of four stages of preparation with elements in each stage designed to meet the individual needs of the target population (such as students or classroom teachers). (Please refer to Figure 1 on page 5.) During *Stage I*, the user is provided with a thorough orientation as to the flow of data within a computerized information system. At this time, the instructional manual concentrates upon directing the user to interact intelligently with the PDP 11/70 CPU by studying the consequences of committing errors in judgment.

The user is gradually disciplined as to inputting correct data, interpreting output, and following directions according to the standardized procedures of the PDP 11/70 operating system. *IPL Module I (Program Orientation)* includes a thorough testing of the user's basic communication skills of reading (interpreting input/output), writing (composing instructions and commands to the computer), and proofing (verifying input/output to ensure its appropriateness. The skill emphasized is "keyboarding."

Even though the computing terminal uses a keyboard similar to that of a typewriter, the discrete difference in its design calls for a modification of the "touch typewriting skill" used in traditional typewriting classes. *IPL Module II (Flow of Data)* has the user document the flow of data within a data processing system by visiting the central computing facility on campus at the University of Delaware. An important component of this visitation is the opportunity to interact with computing personnel at the center in order to familiarize individuals with those with whom they may be communicating via telephone when problems develop.

During *Stage II*, the user completes three instructional modules concentrating upon document generation, text editing, and data base management. During this phase of the DELTA preparatory program, each user becomes knowledgeable in creating and manipulating text and record files as the learner begins to complete an elementary phase in the problem-solving process. *IPL Module III (Information Generation and Editing)* assists the learner in utilizing appropriate procedures for creating a text file and editing the same file within reasonable time restraints. The importance of accuracy

PREPARATORY PROGRAM

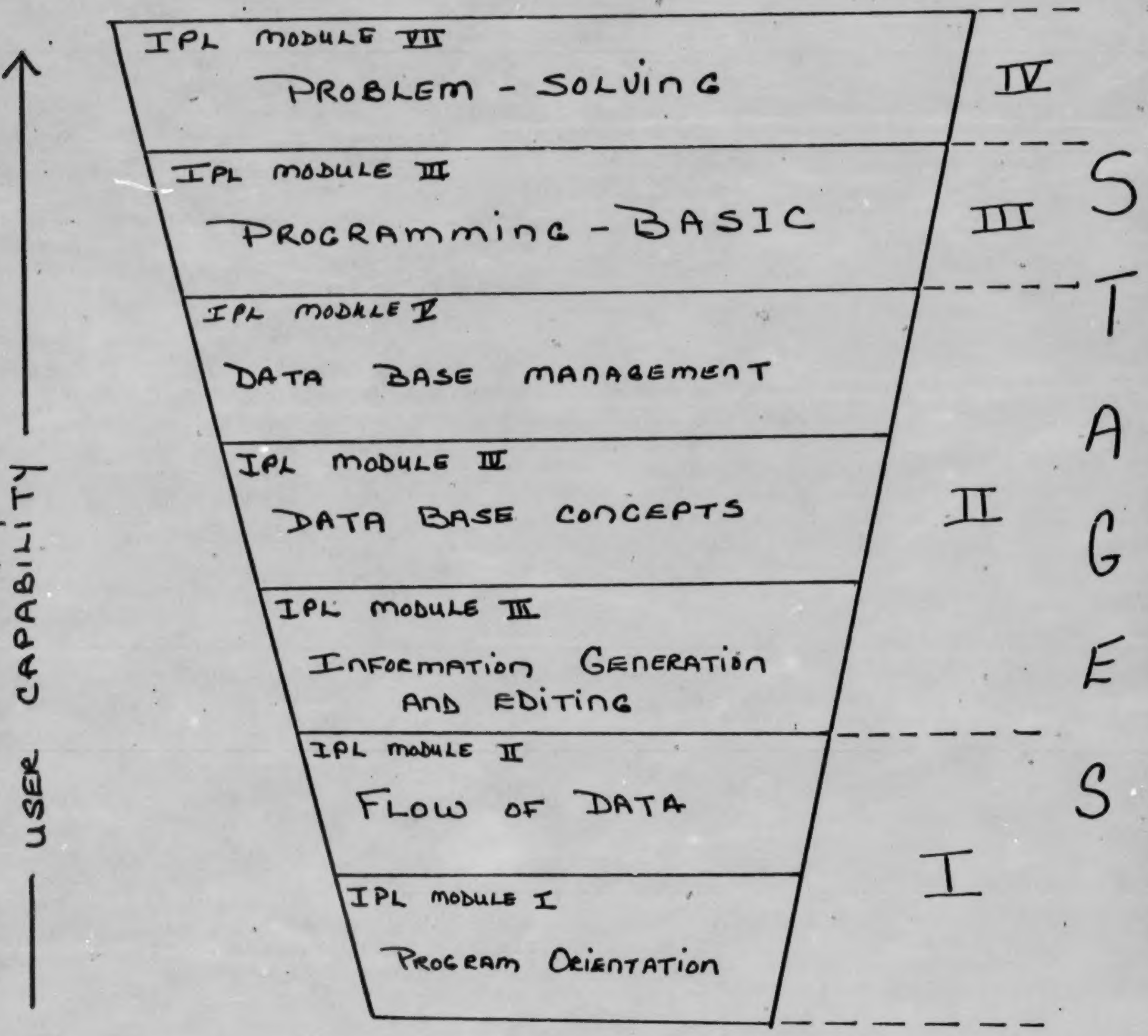
IPL MODULE VII
PROBLEM - SOLVING
IPL MODULE III
PROGRAMMING - BASIC
IPL MODULE V
DATA BASE MANAGEMENT
IPL MODULE IV
DATA BASE CONCEPTS
IPL MODULE III
INFORMATION GENERATION AND EDITING
IPL MODULE II
FLOW OF DATA
IPL MODULE I
PROGRAM ORIENTATION
IV
III
II
I
STAGES
USER CAPABILITY

FIGURE I

INDIVIDUALLY PRESCRIBED LEARNING MODULES FOR COMPUTER EDUCATION

PROJECT DELTA

and applying clear, concise language becomes apparent to students as they complete a variety of exercises in basic information processing. The added dimension of learning how to edit stimulates the development of logic skills so necessary for advanced study in computer usage. IPL Module IV (Data Base Concepts) enables the user to design and establish a small data base. The user learns how to change the contents by adding and deleting information within record files and to manipulate the data base to solve basic information needs. During IPL Module V (Data Base Management), the user completes a series of tasks which enable the development of more sophisticated skills in logic. The experiences in data base management reflect actual business practices (e.g., payroll, customer billing, inventory control, etc.) and permits the user to apply the basic decision making process at different levels of difficulty.

At Stage III, the user is introduced to programming using the BASIC language. Although the user is not expected to become a programmer, he/she is instructed in the BASIC language for the purpose of gaining an understanding as to the capabilities and limitations of his/her problem-solving skills. IPL Module VI (Programming) guides the user in analyzing the problem-solving process in great detail. The activities accomplished in the module assist the new user in recognizing and defining a problem precisely, sequencing steps to solve that problem, and arrive at a solution through the development of a computer program. The BASIC language is used for its simplicity and adaptability in handling simulated business problems. Studying computer programming in this manner enables the user to refine logic skills which become useful for solving more difficult problems for Stage IV in the DELTA computer education program.

During Stage IV, the user is presented with actual business problems in which solutions are sought using the capabilities of the computer. The user is instructed to input appropriate inquiries in an acceptable format via an EDP display terminal and assess appropriate computer files for obtaining needed data for arriving at an accurate decision. During the case-study work, the user must overcome unanticipated obstacles to test his/her ability to identify alternatives for meeting the demands and time restraints called for in each problem. Case studies include learning experiences from simply verifying data in accounts to generating a company's payroll. Learning how to interact by formatting appropriate questions to the CPU, understanding the significance of the response provided, and developing a step-by-step plan of action are the outcomes of the simulated experiences presented during Module VII (Problem Solving).

Conclusions: Impact Upon the Classroom

The integration of computers into every phase of instruction is inevitable. It is imperative for the classroom teacher to initiate steps to incorporate the computer into as many learning exercises as possible in order for students to develop the willingness and maturity to use the tool as part of their daily lives--and of course eventually in a chosen occupation. Resistance to such a movement will place our students at a disadvantage both in their personal lives as well as when seeking employment. From all indications, the computer in one form or another will play a dominant role in the future of everyone's life. The technology marketed today affords the classroom teacher an opportunity for extending the learning capabilities of each individual in today's classroom.

The experimental computer project being conducted in Delaware emphasizes the development of decision-making skills while reinforcing the proper use of the basic competencies of reading, writing, and mathematics. The thrust of the DELTA computer education program is to have students develop a user maturity in a non-technical data management program. Developing appropriate problem-solving skills through simulated business exercises provides the basis for arriving at this computer maturity. These competencies developed through realistic computing experiences complement the competency-based movement in education today. In Delaware, 25 secondary and post-secondary schools are now part of the DELTA project. Classroom instructors in mathematics, business education, and a variety of other disciplines are currently incorporating the computer in their classrooms. With the cost of implementing computer technology becoming competitive with more traditional forms of instruction, the computer terminal will assume a similar importance to classroom instruction as the telephone has served in the past as the basic communication tool in the household.

A Teacher-Controlled, Computer-Assisted Instructional System for Special Education

Alice Chiang
Carolyn Stauffer
Alex Cannara

INTRODUCTION

Computer-assisted instruction (CAI) theoretically holds substantial promise for the field of special education. Much of what is known about the learning characteristics of mentally handicapped children indicates that CAI should be an extremely useful tool in their instruction. This project investigates the potential use of CAI for special education, by developing a CAI system suitable for special education students and by documenting its usefulness and evaluating its effectiveness through an operational demonstration of the system in special education classrooms.

The usefulness of a CAI system largely depends on the appropriateness of the curricula materials it presents for the student population it serves. After surveying CAI 'courseware', it was concluded that existing materials did not accommodate the needs of special education students, mainly because their contents were too difficult, the step size too large, the pace too fast. It was thus necessary to develop materials more suitable for special education students. Because the needs of individual handicapped students are so varied, one set of CAI curricula materials with adaptive decision rules for placement and sequencing did not seem adequate for prescribing instruction. Based on the viewpoints that, for children with learning handicaps, teachers are the best judges of what their students need to learn and that CAI lesson materials should correspond to teachers' classroom activities, the ASSIST (Authoring System Supplementing Instruction Selected by Teachers) teacher-controlled CAI system was developed. This CAI system gives teachers easy authoring capabilities and lesson assignment control as well as convenient management of student information. In this way, instead of imposing upon teachers a developed curriculum with defined sequences that may or may not correspond to teachers' classroom activities, teachers are able to conveniently supplement their classroom instruction with the computer instruction of their choice.

The remainder of this paper describes the central ideas of ASSIST and its implementation in the demonstration program, as well as presents the evaluation results obtained from the demonstration year.

DESCRIPTION OF THE ASSIST SYSTEM

The Authoring System

The purpose of the ASSIST authoring system is to simplify the creation of CAI lessons by allowing teachers to create lessons without having to do any formal programming. To accomplish this, the models approach was adopted.* The idea is to identify common elements in the structure of various lessons and from these to design models of lesson formats that can be used for presenting a variety of lesson materials. For each model, two computer programs are written: (1) an author program that prompts the teacher to enter the contents of a lesson according to the model's specifications and from which it creates a lesson file, and (2) a lesson program that presents lessons to the students from the data in the lesson files according to the model's design. Thus, many different CAI lessons can be created using a few author programs. To create a lesson, teachers need only select a model format, define the lesson contents, and enter this content guided by the prompts of the author program. Author sheets for each model are provided to enable teachers to plan their lessons on paper before entering the lessons into the computer. In this way, a lesson can be created in about 15 mintes. Figure 1 illustrates the authoring process.

To provide a rich variety of formats for creating lessons, ten models have been designed and programmed. Following is a brief description of the ten ASSIST models.

Binary is a question/answer model where the student must select between one of two defined values as the correct answer (e.g., yes/no, true/false, noun/pronoun, same/different.

Choice is a multiple choice question/answer model.

Copy is a perceptual drill model that requires students to copy, or recall and copy items that have been presented.

Drill is a simple arithmetic drill model that randomly generates problems in addition, subtraction, multiplication, and division within certain numerical ranges.

Match is an association exercise that requires the matching of items from one list with those on a corresponding list.

Narrative is a model that simply presents a story or text.

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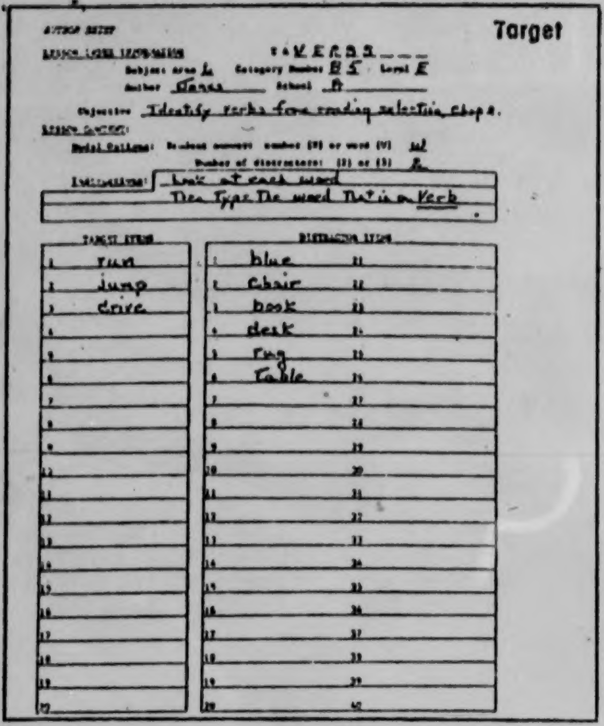
*The concept of the approach owes much to the CAI work done at Lawrence Hall of Science and the California School for the Deaf, Berkeley, California.



AUTHOR SHEET **Target**

LESSON INDEX INFORMATION TAVERBS___

Subject area 1 Category Number B5 Level E

Author Jones School R

Objective Identify verbs from reading selection Chap 2.

LESSON CONTENT:

Model Options: Student answer: number (N) or word (W) W

Number of distractors: (2) or (3) 2

Instructions: Look at each word

Then Type The word That is a Verb

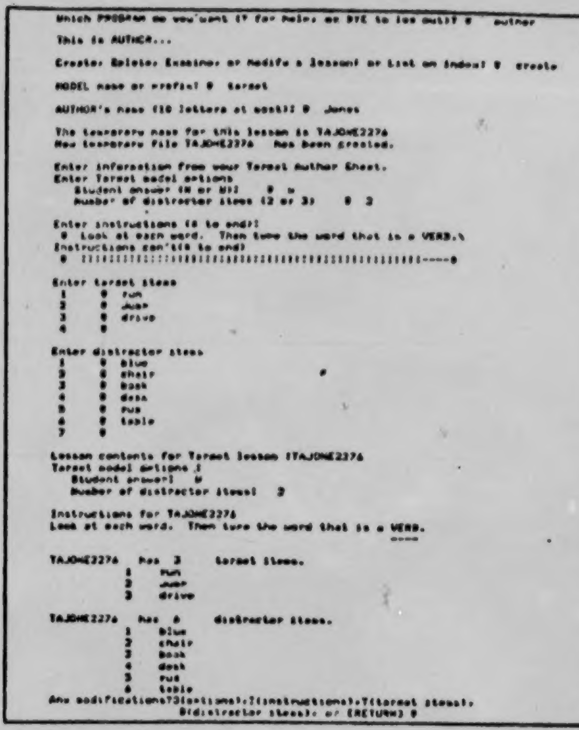
TARGET ITEMS

1 run
2 jump
3 drive

DISTRACTOR ITEMS

1 blue
2 Chair
3 book
4 desk
5 rug
6 Table

Defining Lesson Contents Using Assist Author Sheet



```
Which PROGRAM do you want (? for help, or BYE to log out)? ▶  author

This is AUTHOR...

Create, Delete, Examine, or Modify a lesson, or List an index? ▶  create

MODEL name or prefix? ▶  target

AUTHOR's name (10 letters at most)? ▶  Jones

The temporary name for this lesson is TAJONE2276
New temporary file TAJONE2276   has been created.

Enter information from your Target Author Sheet.
Enter Target model options
   Student answer (N or W)?    ▶  w
   Number of distractor items (2 or 3)    ▶  2

Enter instructions (\ to end)?
 ▶  Look at each word.  Then type the word that is a VERB.\
Instructions con't(\ to end)
 ▶  ::::::::::::::::::::::::::::::::::::::::::::::::::----▶

Enter target items
 1     ▶  run
 2     ▶  jump
 3     ▶  drive
 4     ▶

Enter distractor items
 1     ▶  blue
 2     ▶  chair
 3     ▶  book
 4     ▶  desk
 5     ▶  rug
 6     ▶  table
 7     ▶

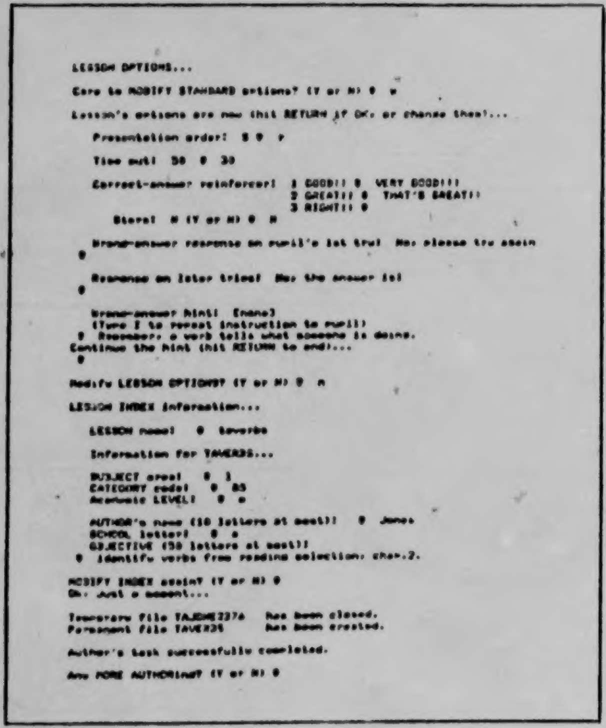
Lesson contents for Target lesson (TAJONE2276
Target model options :
   Student answer?   W
   Number of distractor items?   2

Instructions for TAJONE2276
Look at each word.  Then type the word that is a VERB.
                                                 ----

TAJONE2276   has  3     target items.
             1     run
             2     jump
             3     drive

TAJONE2276   has  6     distractor items.
             1     blue
             2     chair
             3     book
             4     desk
             5     rug
             6     table
Any modifications?O(options),I(instructions),T(target items),
                  D(distractor items), or (RETURN) ▶
```

Entering Lesson Contents Guided by Prompts from the Assist Author Program



```
LESSON OPTIONS...

Care to MODIFY STANDARD options? (Y or N) ▶  y

Lesson's options are now (hit RETURN if OK, or change them)...

   Presentation order?  S ▶  r

   Time out?  30  ▶  30

   Correct-answer reinforcer?  1 GOOD!! ▶  VERY GOOD!!!
                               2 GREAT!! ▶  THAT'S GREAT!!
                               3 RIGHT!! ▶
     Store?  N (Y or N) ▶  N

   Wrong-answer response on pupil's 1st try?  No, please try again
 ▶

   Response on later tries?  No, the answer is?
 ▶

   Wrong-answer hint?  (none)
   (Type I to repeat instruction to pupil)
 ▶  Remember, a verb tells what someone is doing.
Continue the hint (hit RETURN to end)...
 ▶

Modify LESSON OPTIONS? (Y or N) ▶  n

LESSON INDEX information...

   LESSON name?   ▶  taverbs

   Information for TAVERBS...

   SUBJECT area?   ▶  1
   CATEGORY code?   ▶  B5
   Academic LEVEL?   ▶  e

   AUTHOR's name (10 letters at most)?   ▶  Jones
   SCHOOL letter?   ▶  r
   OBJECTIVE (50 letters at most)?
 ▶  Identify verbs from reading selection, chap.2.

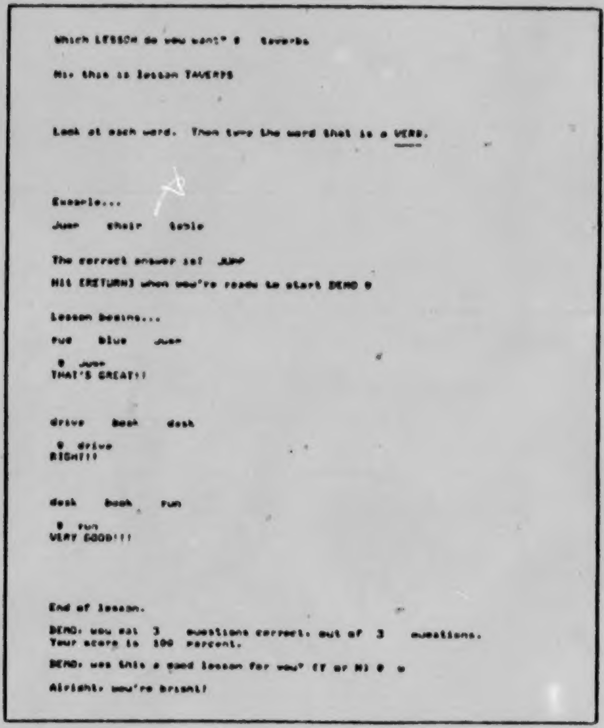
MODIFY INDEX again? (Y or N) ▶
Ok, just a moment...

Temporary file TAJONE2276   has been closed.
Permanent file TAVERBS      has been created.

Author's task successfully completed.

Any MORE AUTHORing? (Y or N) ▶
```

Entering Lesson Options and Index Guided by Prompts from the Assist Author Program



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Which LESSON do you want? ▶   taverbs

Hi, this is lesson TAVERBS


Look at each word.  Then type the word that is a VERB.
                                                 ----


Example...

jump    chair    table

The correct answer is?  JUMP

Hit (RETURN) when you're ready to start DEMO ▶

Lesson begins...

rug    blue    jump

 ▶  jump
THAT'S GREAT!!


drive    book    desk

 ▶  drive
RIGHT!!


desk    book    run

 ▶  run
VERY GOOD!!!



End of lesson.

DEMO, you got  3    questions correct, out of  3    questions.
Your score is  100  percent.

DEMO, was this a good lesson for you? (Y or N) ▶  y

Alright, you're bright!
```

Student Lesson Protocol

Figure 1. ASSIST Authoring Process

Position requires students to select the number associated with a word or space in a sentence that correctly answers the question.

Question is a question/answer model that requires a key word answer.

Spell requires the verification of a correctly spelled word or if mispelled, the entry of the word spelled correctly.

Target requires the identification of an item belonging to a particular category from several items that do not belong.

Seven lesson-interaction options have been included in all ASSIST model programs to give additional flexibility in the lesson design. These options are (a) random or sequential presentation order, (b) length of time out, (c) correct answer reinforcers, (d) use of stars as reinforcers, (e) and (f) wrong answer responses on the first and subsequent tries, and (g) wrong answer hints. The author/teacher may simply accept standard options as programmed or may enter individual choices for these options through the queries of the author programs.

All lessons available through the ASSIST system can be stored in the system's public library and are catalogued in a subject area directory and a model directory. From these indexes, teachers can easily select lessons to assign to their students. As a lesson is created, it is entered into the lesson indexes and initially is stored in the user's private library, but may be moved to the system's public library and become available to all users. In this way, the library of ASSIST lessons is constantly increasing.

In addition to creating lessons, teachers may also examine, modify, and delete existing lessons, and list indexes by subject area or model.

Student Management Facilities

In order to take a lesson on the ASSIST system, students must first be enrolled. Teachers control the enrollment of their students, through an enrollment program (PUPIL). To further individualize lessons for each student, at enrollment time teachers may specify six special needs that determine the forms and procedures for presenting lessons for each student. These special needs include (a) upper-case presentation only, (b) extra vertical spacing between lines, (c) display of log-on messages, (d) review of incorrect items, (e) presentation of student scores, and (f) obtaining student opinion of lessons. The purpose of this feature is to allow teachers to adapt lessons to students' needs without having to create additional lessons for each student.

Teachers may pre-assign lessons to individual students or request a specific lesson for a student at sign-on time. This dual lesson selection procedure allows teachers to pre-plan individual students' lesson assignments as well as make alternate lesson selections according to the student's most recent activities.

Reports of student progress provide timely information on students' performance and indicate students' mastery of concepts or areas in need of remediation. Teachers (via the REPORT program) can choose among six different types of reports to obtain information about particular students or about an entire class for any specified time period. In this way, teachers can easily monitor students' progress.

Lastly, teachers may send messages to individual students through the PENPAL program. Figure 2 summarizes the ASSIST programs available to teachers for the above described functions. A more detailed description of the ASSIST system can be found in the ASSIST System Documentation (Chiang & Cannara, 1978).

The Student Taking a Lesson

The ASSIST models lend themselves to drill and practice lessons, which supplement a teacher's classroom instruction. By and large, these lesson presentation procedures follow the standard CAI protocol of item presentation, response evaluation, and feedback. Within the constraints of these simple lesson-presentation procedures, several student options and more personalized presentation features have been added.

When a student completes a lesson, the student's performance on the lesson is recorded on his/her history. A separate history file is kept for every enrolled student and is used for student reports. Students may also send messages via their terminals to assigned penpals, teachers, or other students. This communication capability provides a communication link among students and is intended to give students further motivation for using the system.

A theoretical advantage of CAI is that instruction can occur on a one-to-one basis between the student and the instructional system. This, however, demands more wisdom and ability than CAI designers have yet acquired. In some system-controlled CAI systems, the system individualizes instruction by selecting appropriate lessons for students by algorithmically estimated student needs and lesson hierarchies. In the ASSIST system, the judgment of individual students' needs and selection of appropriate lessons are external to the system and are under teacher control. The ASSIST system aids teachers in individualizing instruction by providing teachers with easy means of lesson creation and assignment and with reports of student progress. The system does not pretend to understand the students' thinking or his/her needs and does not prescribe instruction for students.

The Hardware Configuration

The computer used for implementing ASSIST was a standard mini-computer time-sharing system, the BTI-4000, produced by Basic Timesharing

FLOW OF CAI-SYSTEM PROGRAMS THAT ARE UNDER DAILY TEACHER CONTROL

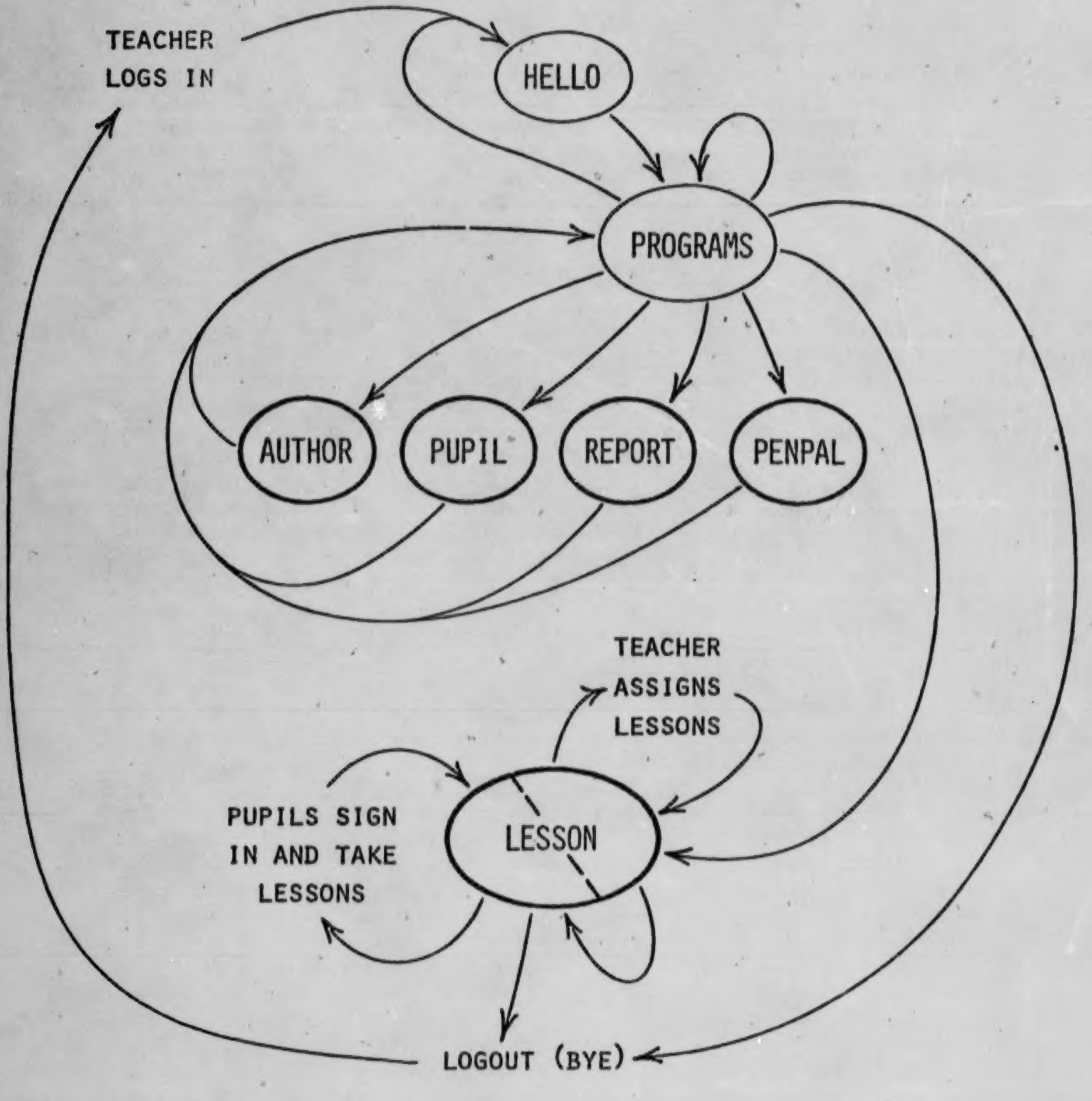
TEACHER LOGS IN
HELLO
PROGRAMS
AUTHOR
PUPIL
REPORT
PENPAL
TEACHER ASSIGNS LESSONS
PUPILS SIGN IN AND TAKE LESSONS
LESSON
LOGOUT (BYE)

Figure 2. ASSIST Programs

Incorporated. It is a 16-bit (2 byte) word machine with 32 kilowords of fast memory. The configuration chosen was a 16-port (16 terminal) system with 20 megabytes (20 million characters) of disk storage. All programs were written in the Basic programming language. The terminals used were Decwriters, 30-character per second teletypewriter terminals produced by Digital Equipment Corporation. Modems (telephone line multiplexors) produced by Prentice Electronics were used along with four-wire telephone lines to provide the telecommunications. All equipment chosen proved to be extremely reliable. Down time for the computer totaled 16 hours, or approximately .002% of total run time. Down time for terminals averaged approximately 4 hours per terminal throughout the 35 weeks of the project's operation.

DESCRIPTION OF THE DEMONSTRATION PROJECT AND EVALUATION RESULTS

In order to demonstrate the use of ASSIST, the system was installed in special education learning centers in the Cupertino Union School District (CUSD), California, and was operational for the 1977-1978 school year. The purpose of the demonstration was to show that CAI can operate reliably and effectively in a special education environment and to evaluate the usefulness of this teacher-controlled CAI system as well as its cognitive impact on children with learning handicaps. A brief description of the demonstration and evaluation follows. A more detailed description can be found in the final report by Chiang, Stauffer & Cannara (1978).

Demographics of the Demonstration Sample

Cupertino School District is one of northern California's largest elementary school districts, serving nearly 20,000 students in 30 elementary schools, 6 junior high schools, and one school for the mentally retarded. Each school in the district has a learning center that serves children with exceptional needs. Children come to a center for special help according to each child's individual educational prescription; emphasis is placed on 'mainstreaming' or placing children in the least restrictive environment. Children with more severe handicapping conditions are assigned to self-contained centers or special schools. The district's careful procedures for identifying handicapped students, their approach towards individualizing instruction for these students through the individual educational plans (IEP), and the existence of established learning centers made CUSD an ideal district for housing the CAI demonstration project.

Eight schools (four elementary and four junior high) were selected for participation based on the distribution of types of handicapped students in the school, on the ages of these children, and on the willingness of the teachers to participate. Four types of handicapped students were served by the demonstration project. These groups are (1) the educable mentally retarded (EMR), (2) the educationally handicapped minors (EHM), (3) the learning disability group (LDG), and (4) the severe oral language handicapped (SOLH).

These four handicapped groups were selected first because they represent the largest group of handicapped children; second because they are not physically impaired, thus do not require special terminal equipment; and last because common instructional strategies could be used for their treatment, i.e., positive reinforcement, repetition, immediate feedback, small increments of curriculum material and short sessions. Approximately 200 students between the ages of 7 and 16 participated in the project. No student had exposure to CAI prior to their participation in this project.

Operations of the CAI Program in the Learning Centers

The learning centers were spacious, well equipped resource centers, with well defined subject matter location where students were scheduled individually or in small groups for instruction according to each student's individual education plan. The activities and atmosphere in each center was defined by the learning center's teacher(s), and varied from a quiet, structured, and disciplined environment to one of more movement, noise, and apparent activity. Depending on the size of the student population in a center, one to three computer terminals were installed in each of the eight centers. In general, the terminals were well integrated into the learning center environment, and were not disruptive of other ongoing activities.

Scheduling and operation of the system was left to the teacher's judgment. In some centers, students were scheduled for regular use of the system; in others, scheduling was less structured and assignment to system use remained flexible. Selection and assignment of lessons for the students were determined by the teachers, but in some cases, teacher aides supervised the mechanics of the system's use.

Fundamental to the operation of the ASSIST system is the premise that a public library of teacher-created lessons will be developed during the course of its use and that teachers can share in the use of these lessons. To implement the sharing, a directory of ASSIST lessons was constantly updated as new lessons were created and was available to teachers in its entirety or in a partial listing of the most recently created lessons. To further facilitate this sharing process, descriptions and samples of new lessons were distributed to the teachers monthly. By establishing this network for sharing lessons, it was anticipated that the need for teachers to create new lessons would diminish.

The success of the ASSIST system depended on the teachers' understanding of the instructional functions of the system, their perception of its usefulness, their ability to easily manipulate it and their willingness to use it. Therefore, efforts were made to involve the 14 teachers and 8 teacher aides in the development of the system, to train them to understand its applications and its mechanics, and to assist them in its use.

Evaluation Results

The demonstration that a CAI system is reliable and useful represents an accomplishment in its own right. However, educational evaluation practices require more quantitative evidence of the effectiveness of an innovative project. To this end, three types of data have been collected to evaluate the effectiveness of this project. First, to assess the utility of the ASSIST system in special education classrooms, the system recorded moment-to-moment information on the system's use, which included school usage, lesson usage, lesson creation, and student performance. Second, to assess the cognitive impact of the CAI program on handicapped children, pre- and post-achievement tests were administered to CAI treatment group students and their matched control group students to compare achievement gains. Third, a series of questionnaires was administered to teachers, students, and principals to assess their opinions of the system. The results are summarized below.

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System Usage

The amount of system usage by student varied among the schools, with the minimum being 2.75 lessons and 17 minutes per week and the maximum being 11.6 lessons and 96 minutes per week. This range of the use among the participating schools indicates that differences existed between them in how CAI was integrated into their learning centers. Some of the observed differences in the structures of the learning centers that contributed to the usage variation are school's scheduling, level of student ability, group versus individual instruction, degree of program establishment, and teacher involvement.

Although student use was relatively low in comparison to total classroom time, the extent of use was consistent with the project's intent and was what could be expected in the first year of operation, given the following limitations: (a) hardware resources were necessarily limited to a few terminals per center, thus requiring more scheduling effort on the part of the teacher; (b) only two of the learning centers were self-contained and in the others students came to the center for limited time periods; (c) teachers not only had to schedule students, but also had to develop and sequence their instructional materials in this first year of operation--a process that was demanding of their time and preparation. Given these scheduling and first-year constraints, usage was quite remarkable.

Lesson creation. A total of 975 lessons were available on ASSIST by the end of the project year. Of these, 164 lessons were created by the project developers prior to the program's operation. The remaining 811 lessons were authored by the 14 participating teachers, averaging 57 lessons per teacher or an overall average of 90 lessons per month. Most of the lessons, however, were created during the first four months of operation; the need for new lessons diminished as the library of lessons increased during the year.

Of the 811 teacher-created lessons, 687 were in language arts and reading and 124 in math. It is interesting to note that in the past, CAI projects have been predominantly oriented towards math drill and practice and lacked adequate lessons in reading or language. The ASSIST model formats seemed to lend themselves easily to the creation of simple language lessons and thus filled this need in their development. The greatest number of lessons developed in the reading and language areas were in vocabulary development, followed by lessons in factual detail, main ideas, and sentence structure. In math, the additional teacher-developed lessons were in multiplication and number concepts.

The lesson creation process changed during the course of the project. Whereas initially teachers were more concerned with the mechanics of entering a lesson into the system, once they mastered this procedure, their efforts were directed toward creating more imaginative and sophisticated lessons; thus, the quality of lessons noticeably improved as the teachers became more comfortable with using the system.

The authoring capabilities proved to be simple and useful. Whereas 40 hours of development time for one hour of instructional material has been a rule of thumb for developing CAI lessons, the ASSIST models and programs enabled teachers to create a lesson in a matter of minutes. This ease of authoring resulted in numerous lessons being created during the demonstration year.

The data indicate that on an average, a lesson was used 22 times, of which approximately 57% of its use was by the originating school and 43% by other schools. This indicates that teachers did use lessons created by other teachers and that the sharing network was effective.

Cognitive Impact

A matched group design was used for the cognitive evaluation. For each of the four elementary and four junior high school subgroups in the treatment group, a control group from other CUSD schools was selected whose population was similar in age, in the type of handicap, and in socioconomic status. Pretests and posttests were administered to all the students in the treatment and control group. The tests used were the KeyMath Diagnostic Arithmetic Test and the Reading Recognition and Reading Comprehension subtests of the Peabody Individulized Achievement Test (PIAT).

For each of the treatment and control groups, the means and standard deviations of their pretest and posttest raw scores for all three tests, and the correlations between the pretests and posttests were computed. Although each treatment and control group was matched for ability, differences in the mean pretest level often occurred. To account for the differences in the pretest scores, the control groups' posttest scores were adjusted, based on pretest differences, using the analysis of covariance method of adjustment. Gains for each group were computed by subtracting the pretest scores from the posttest scores. The control group gain was then subtracted from the treatment group gain to obtain the treatment gain score (beyond the control group's gain). An adjusted treatment gain was also computed by comparing the treatment group posttest with the adjusted control group posttest. Finally, a T-test for significant mean differences between the treatment group posttest score and the control group adjusted posttest score was computed. All the above described statistics are presented in Table 1.

The results indicate that testing was reasonably reliable, with good pretest-posttest correlations (mostly in the 90s), few outliers, and no evidence of test non-linearity. As can be expected from differences in subject matter, the reliability of the math testing was highest and that of reading comprehension was the lowest. The dispersion of scores as shown by the standard deviations and the scatter plots was substantial, which indicates a wide range of student ability in most groups.

The treatment group gains were positive in 3/4 of the cases and significant at the 80% level in nearly half the cases. This overall,

Table 1. Summary Statistics for Treatment and Control Groups by School

School	Test	TREATMENT GROUP						CONTROL GROUP						GAINS					
			Pretest		Posttest		Corr. Pre/ Post		Pretest		Posttest		Corr. Pre/ Post	Posttest minus Pretest		Treatment Gain			
Elem.		N	Mean	SD	Mean	SD		N	Mean	SD	Mean	SD		Treat- ment	Con- trol	Beyond Control Group	Ad- justed	T	1 - σ
A	KM	11	28.7	9.9	37.1	8.2	.91	11	39.9	5.9	46.5	8.7	.88	8.4	6.6	1.8	1.96	.54	.70
	RR	11	15.7	4.9	19.5	2.2	.51	11	21.9	3.2	23.8	3.4	.84	3.8	1.9	1.9	-.79	-.66	.75
	RC	11	15.2	4.4	19.7	2.3	.34	11	21.5	3.4	21.5	2.9	.88	4.5	0	4.5	1.18	1.07	.85
E	KM	11	115.7	35.9	135.7	37.6	.98	9	95.4	30.9	105.7	35.9	.92	20.0	10.3	9.7	8.85	.54	.70
	RR	11	31.4	9.2	38.2	8.8	.95	9	33.7	13.0	35.4	11.9	.88	6.8	1.7	5.1	4.71	1.01	.85
	RC	11	31.5	10.1	38.6	10.8	.90	9	31.8	12.4	36.0	12.2	.70	7.1	4.2	2.9	2.90	.56	.70
S	KM	21	104.5	27.4	123.5	27.3	.95	29	93.4	25.2	112.5	28.9	.81	19.0	19.1	-.1	.65	.08	--
	RR	21	31.1	8.1	36.9	7.9	.94	29	30.2	10.1	36.2	10.3	.90	5.8	6.0	-.2	-.20	-.07	--
	RC	21	30.0	9.7	37.7	9.8	.84	29	32.2	12.9	36.4	10.9	.79	7.7	4.2	3.5	3.02	1.00	.85
G	KM	22	107.3	37.6	128.1	36.0	.97	23	94.7	38.8	110.9	37.4	.98	20.8	16.2	4.6	5.34	.49	.70
	RR	22	34.8	12.2	41.4	12.3	.97	23	31.7	9.7	35.3	9.0	.93	6.6	3.6	3.0	3.29	1.03	.85
	RC	22	36.3	13.4	41.1	12.3	.94	23	29.5	11.2	34.3	9.6	.83	4.8	4.8	0	1.51	.40	.70
Jr.Hi.																			
K	KM	32	147.7	18.3	157.7	19.1	.87	24	158.5	16.7	162,6	17.5	.92	10.0	4.1	5.9	5.00	1.00	.80
	RR	32	42.7	11.3	45.1	10.2	.92	24	47.4	8.8	48.8	8.1	.90	2.4	1.4	1.0	.24	.10	--
	RC	32	42.4	8.5	47.4	10.6	.75	24	46.0	9.0	50.4	10.4	.64	5.0	4.4	.6	-.05	-.02	--
O	KM	27	148.6	29.7	149.4	30.1	.98	19	149.3	25.0	156.8	24.5	.94	.8	7.5	-6.7	-6.70	-.80	.80
	RR	27	42.3	10.3	47.8	11.7	.94	19	46.0	10.3	43.0	10.7	.89	5.5	-3.0	8.5	8.50	2.54	.99
	RC	27	46.9	13.5	46.7	10.9	.86	19	45.5	12.0	47.2	13.1	.85	-.2	1.7	-1.9	-1.59	-.45	--
C	KM	25	145.1	18.7	163.0	17.5	.86	19	149.3	25.0	156.8	24.5	.94	17.9	7.5	10.4	9.78	1.55	.90
	RR	25	46.7	11.0	49.0	9.2	.95	19	46.0	10.3	43.0	10.7	.89	2.3	-3.0	5.3	5.37	1.80	.95
	RC	25	42.0	6.9	47.5	6.1	.74	19	45.5	12.0	47.2	13.0	.85	5.5	1.7	3.8	3.00	1.01	.86
M	KM	15	70.5	30.5	85.9	34.4	.98	7	66.7	14.0	77.0	17.4	.90	15.4	10.3	5.1	4.75	.34	--
	RR	15	33.7	12.2	35.8	12.5	.98	7	28.6	8.0	30.3	9.0	.99	2.1	1.7	.4	.10	.02	--
	RC	15	30.7	10.9	31.5	9.0	.87	7	24.7	5.7	28.6	3.5	.87	.8	3.9	-3.1	-1.09	.30	--

KM = KeyMath
RR = PIAT Reading Recognition
RC = PIAT Reading Comprehension

moderate gain for the treatment group is a reasonable outcome, given the fact that student time on the computer was limited to about 30 minutes per week. In fact, a larger gain would be more difficult to explain. The highest gains were made in the reading recognition test, followed by math, then by reading comprehension. This result is also not difficult to explain, since most of the CAI lessons created were drills in reading recognition skills. Reading comprehension is much more difficult to teach with such exercises.

To validate the results of the control group evaluation, we further compared the treatment group's performance with the national norm data provided by the test publishers. The comparable results from both evaluation methods provide us with some confidence in the existence of a moderate overall gain for the treatment group students.

In the interest of determining whether the treatment interacted differently with students of different handicaps, a 2 x 4 factor analysis of covariance, with the pretest as the covariate and the handicap type and treatment as the two variates, was computed separately for the junior high and the elementary schools for each of the three tests. The results are presented in Table 2. Note from this table that the treatment effect was significant at .90 or above for four out of six possible combinations of test and school levels. Handicap type was a significant correlate of test performance for the reading comprehension test in the elementary schools. The interaction of treatment and handicap type was significant only in the case of reading comprehension in the junior high school.

In summary, results of the cognitive outcome evaluation seem to be reliable and indicative of cognitive benefits to the students from their exposure to CAI. This can be considered a remarkable result, given that students spent an average of only 30 minutes per week taking CAI lessons.

Questionnaires. To assess the opinions of teachers, students, and principals towards the CAI project, questionnaires were administered to these groups at the end of the demonstration year. In addition, teachers were given questionnaires at the beginning and middle of the project to follow their progress.

On the whole, the participating teachers were highly favorable to the use of CAI throughout the demonstration period with 83% being very satisfied with the project and 87% viewing CAI as a very useful and promising method of supplementary instruction. When asked their opinion of the approach of this project, where teachers develop and share lesson materials, 94% thought it very effective and liked it very much. Teachers estimated that they spent two to three hours per week preparing lessons for the CAI project, and 83% thought it was a very worthwhile use of their time. About half of the teachers thought lessons created by other teachers were very useful and half thought they were somewhat useful. Forty-two percent of the teachers said they created one-fourth of the lessons they assigned; 19% created one-half of the lessons; 24% created three-fourths of the lessons; 15% created all the lessons. These results indicate that most teachers liked the control of lesson creation and lesson selection, and participated

Table 2

Analysis of Covariance (2x4) with Pretest as Covariate and Handicap Type and Control/Treatment as Variates

	Elementary				Junior High			
	SS	df	MS	F	SS	df	MS	F
KEYMATH								
Handicap Type	231.6	3	77.2	.33	1,498	3	499	3.99**
Treatment	77.3	1	77.3	.33	587	1	587	4.19**
Interaction	68.6	3	22.9	.10	143	3	48	.38
Within Cell	31,165	133	234		17,561	133	125	
PIAT READ.REC.								
Handicap Type	33.4	3	11.1	.29	43	3	14.3	.58
Treatment	110.5	1	110.5	2.89*	187	1	187	7.60***
Interaction	24	3	8	.20	84	3	28	1.14
Within Cell	5,092	133	38.3		3,275	133	24.6	
PIAT READ.COM.								
Handicap Type	430	3	143	2.23*	214	3	71.3	1.23
Treatment	189	1	189	2.95*	6.1	1	6.1	.01
Interaction	158	3	52.7	.82	532	3	177.3	3.06*
Within Cell	8,606	133	64		7,710	133	58	

$^{*}F(3,120)_{.90} = 2.13$

$^{**}F(3,120)_{.95} = 3.92$

$^{***}F(3,120)_{.99} = 6.85$

actively in this process. Assignment of lessons to students and student scheduling seemed to be the areas of most problems for the teachers; few mentioned any difficulties with the authoring procedures or the mechanical aspects of the system's use.

After the posttest, students were interviewed by the testers with a brief set of questions regarding their views of the CAI project. Of the 113 students questioned, 85% liked the CAI project and felt the computer lessons helped them. Ninety-three percent thought it was fun, 84% did not think that it was a waste of their time, 75% thought it was neat and not boring, and 85% wanted the computer to stay in their learning center.

Principals in the eight participating schools were supportive of the project from the start and highly favorable of its impact on special education. Eighty-seven percent of the principals felt CAI was a useful supplemental teaching method and in their opinion, students in the learning centers had benefited a great deal.

CONCLUSIONS AND RECOMMENDATIONS

The belief that CAI should serve teachers as a supplemental instructional resource in special education classrooms led us to the development of a teacher-controlled CAI system for special education that gave teachers easy authoring and student-management capabilities. This project demonstrated that such a system can operate reliably and successfully in special education classrooms, as evidenced by the ease with which teachers incorporated CAI instruction with their classroom activities, the large number of lessons they created, the extensive student use of the system, and the overwhelmingly positive response from teachers and students towards the system. Cognitive evaluation of the educational benefits of the system for handicapped students indicated that some gains were made by the treatment group students. Given the fact that this was the first year of operation and that students were exposed to the system for only appoximately 30 minutes per week, we consider such gains noteworthy.

We conclude that a teacher-controlled CAI system, such as the one developed for this project, is a useful and effective system for special education classrooms and make the following recommendations for its continued development:

(1) For some educationally handicapped students, the printed text is too limiting a medium for presenting instructional materials. The capability to present audio and graphic materials should be extended to future systems.

(2) One of the factors influencing the more limited student use of the system was that it was not economically feasible to have many terminals in one classroom. With the advent of microcomputers, it should be possible to afford several such standalone computers in one classroom. We recommend that the ASSIST system or the ideas of the system be translated into programs for microcomputers. The major logistic difficulty of using microcomputers is that there will be no default means of communicaton among users, and the sharing of lessons will have to be accomplished off-line, by a disc or tape library service.

(3) Individual educational plans are mandated by Congress for all special education students. The ASSIST system can be expanded to assist teachers in the management of students' IEPs by developing a student-management system component that relates students' classroom and computer activities with his/her IEP.

It is hoped that the ideas put forth in the ASSIST system and some of the above recommendations will be carried out in future development of CAI systems.

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Instructional Strategies for Vocabulary Development in the Context of a Prescriptive Model

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The Setting and Development Objectives

The CAI development that we wish to report in this paper is directed toward enhancing vocabulary knowledge of low-verbal skills college students. The instructional design of the CAI system is a simple pretest, instruction, posttest design. The words to be taught have been selected from existing frequency lists with special attention to their "power" (occurrence in a wide range of reading materials). The sites at which the instruction will be used will be developmental reading laboratories at the campuses of a university and/or a community college.

In this paper, we wish to report the progress we have made on the design of our CAI system and the results of two studies that have helped us sharpen the methodology of our instructional research in vocabulary and that have provided preliminary information on the relative effectiveness of two of the instructional modules.

Theoretical Framework and Research Objectives

We are developing a variety of strategies for instructing the words that, according to the pretest, a given student may need to learn. Some of the strategies we have built are similar to those found within developmental reading materials; others are quite different (see later section for a detailed description of the strategies). We have specified a number of performance objectives as the goals of our vocabulary instruction and each of the strategies is focused on one of these performance objectives. Our objectives (O_i) refer to terminal behaviors such as being able to define a word, use it in a sentence, classify instances of the word properly and so forth.

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There are some particularly intriguing aspects of our instructional situation. Previous research (e.g., Johnson and Stratton, 1966) has shown that one of the likely characteristics of several of our instructional strategies is that they may provide more instructional returns than one might ordinarily expect. It is likely that a given strategy will have an effect on the objective it is directly related to and on other objectives. Each of our instructional strategies, therefore, appears to contribute to the acquisition of more than one objective. Thus, we might restate the matter by saying a strategy has both a direct effect (on the objective it is directly related to) and an indirect effect (on other objectives). The interesting problem as we see it is to develop rules for deciding the best mix of strategies, when certain levels of achievement on tests of the objectives are desired. The rules, of course, would be formulated to take into account both the direct and indirect effects of the given strategies. The rules will also take into account the instructional "costs" associated with given individual modules or combinations of modules. We currently view "costs" to be amount of student time.

In collaboration with Guy Groen, we have developed a quantitative representation of the design problem we face and it takes the following form:

1. There are n learning outcomes, O_i (objectives).

2. For each O_i, there exists a method M_i and a criterion test, CT_i.

3. M_i yields a higher score on CT_i than M_i does on CT_j. Comment: This assumption reflects the admonitions of Gagné and others that instruction that is highly consistent with tests that measure its

effects leads to greater achievement than instruction that is less consistent. We shall drop the assumption if it does not hold in our particular application. This will in turn mean that we can allow arbitrary selection of M_i's when composing prescriptions.

4. Each M_i has an associated cost, c_i.

5. Each CT_i has a lower bound of acceptable performance, lb_i.

6. Each M_i has a direct effect $\sigma_{ij} > o$ on CT_i and an indirect effect $\sigma_{ij} > o$ on each CT_j $(j \neq i)$ such that

$$CT_i = \sum_{j \in S}^{\{S\}} \sigma_{ij}$$

when S is the set of methods being used.

Comment: The σ_{ij}'s are supposed to be fixed effects. Thus, CT_i varies depending on which σ_{ij}'s are in the linear combination.

Clearly, as the formulation shows, the central problem for this stage of our research is how to determine the σ_{ij}'s, since they are the determiners of level of achievement on a given criterion test. We are adopting two approaches to determining the σ_{ij}'s. One approach we call bottom-up, which means that we shall determine the σ_{ij}'s from the pattern of criterion test scores that are obtained after students receive instruction via a given set of modules. The second approach we call top-down and it assumes that each of the modules has a structure that can be denoted in various ways. One model of structure that we have worked out so far involves simply decomposing the modules into their instructional routines. Each module can be analyzed into component routines serving different psychological functions, and some routines are common to some modules.

Both approaches, bottom-up and top-down, lead to interesting testable predictions about patterns and levels of achievement on the criterion tests as a function of what modules are used in the students instructional prescription. We shall not explore the full set of predictions that can be generated from the model here; we shall, however, show one interesting consequence of (6) on page 3. It is possible to derive the theorem:

$$7. \quad CT_1^{\{1,2\}} + CT_2^{\{1,2\}} > CT_1^{\{1\}} + CT_2^{\{2\}}$$

The theorem can be shown to be true in this manner:

$$CT_1^{\{1\}} = \sigma_{11} \text{ and } CT_2^{\{2\}} = \sigma_{22}.$$

Thus,

$$CT_1^{\{1\}} + CT_2^{\{2\}} = \sigma_{11} + \sigma_{22}.$$

But,

$$CT_1^{\{1,2\}} + CT_2^{\{1,2\}} = \sigma_{11} + \sigma_{22} + \sigma_{12} + \sigma_{21};$$

and so,

$$CT_1^{\{1,2\}} + CT_2^{\{1,2\}} > CT_1^{\{1\}} + CT_2^{\{2\}}.$$

The above theorem is tested in an experiment comparing student achievement summed on two criterion tests as a function of instructional modules (1 or 2 only vs. 1 and 2) received. Our research in the forthcoming months will be directed toward testing theorems such as (7) previously mentioned. We shall initially be concerned with developing our prescriptive rules as they apply to groups of students; eventually we hope to be able to apply the formulation we have developed to the learning of individuals, for one might reasonably expect individuals to differ in their propensity to transfer (i.e., the magnitude of indirect effects ought to vary among individuals).

Exploration of the previously described model that we think governs construction of instructional prescriptions in vocabulary shows that it has some interesting consequences. The key concept of the model is the existence of indirect effects. If indirect effects do not exist, then the question of what constitutes the most appropriate prescription is uninteresting, because in order to develop each one of a set of performance objectives, each of the methods must be used. Therefore, the major purpose of the first stages of our research has been to demonstrate that indirect effects exist. Of course, to enhance the chances that the methods we develop do in fact produce indirect effects, we have incorporated the methods used in the 1966 study which were, in turn, based upon methods found in the developmental reading literature.

Our purpose in this paper is to describe the seven instructional modules we have developed in terms of the design guidelines used to create them and in terms of their component routines. We also include displays of the instruction as it will appear on the CRT, for visual displays show instructional task content in ways that are not easily captured in text descriptions. We shall also describe some research of a preliminary nature that bears on the question of the existence of indirect effects.

This section will describe the DEFINE, CLASSIFY, WORD RELATIONS, WORDS IN CONTEXT, WORD LINE, DISCOVER and EQUIVALENTS modules. Each module comprises smaller segments of instruction called routines - each routine corresponding to a change in the stimulus-response situation. The routines were designed to follow a shaping procedure, i.e., gradually reducing the stimulus support for the terminal response as the module procedes. Routines are of two kinds: expository and inquisitory. Some routines occur in more than one module. Table 1 lists and briefly describes all routines for all seven

TABLE 1

Modules and Their Component Routines

DEFINE	CLASSIFY	DISCOVER	WORD RELATIONS	WORD LINE	WORD IN CONTEXT	EQUIVALENTS
1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Multiple Choice (Inq.)
2. Introductory Definition (Exp.)	2. Introductory Definition (Exp.)	2. Introductory Examples (Exp.)	2. Introductory Definition (Exp.)	2. Introductory Definition (Exp.)	2. Type from Memory (Exp.)	
3. Type from Memory (Exp.)	3. Example/ Nonexample (Inq.)	3. Forced Choice of Example (Inq.)	3. Forced Paraphrase (Inq.)	3. Forced Paraphrase (Inq.)	3. Story (Exp.)	
4. Definition with Attribute Labeling (Exp.)	4. Forced Choice of Example (Inq.)	4. Practice (Inq.)	4. Type from Memory (Exp.)	4. Type from Memory (Exp.)	4. Type Word (Exp.)	
5. Multiple Choice Paraphrase (Inq.)	5. Forced Choice Example Summary (Exp.)	5. Illustrative Definition (Exp.)	5. Explanation of Relations (Inq.)	5. Illustrative Line (Exp./Inq.)	5. Questions (Inq.)	
6. Multiple Choice Definition Construction (Inq.)	6. Practice (Inq.)		6. Practice Relations (Inq.)	6. Map Line (Inq.)	6. Type Word (Exp.)	
7. Definition Construction (Inq.)			7. Relations Summary (Exp.)	7. Line Summary (Inq.)	7. Sentence Completion (Inq.)	

modules and can be consulted to compare them. It will be noted that some routines use a response contingent criterion for exit; others do not.

Define Module

The define module consists of seven routines.

Routine 1: Pronounce. This routine presents the target word and a phonetic pronunciation key, with the direction to the student to pronounce the word. This routine begins six of our seven modules.

Routine 2: Definition. An extended definition of the target word is shown, emphasizing the critical attributes by separating them visually from the rest of the display. The student is instructed to read the definition.

Routine 3: Type from Memory. While the definition remains on the screen the student is instructed to look carefully at the word until ready to type it from memory. The student then types the word after the stimulus disappears from the screen. Feedback either confirms a correct response or presents the word again, which is retyped by the student with the word in view. (Figure 1 presents screen displays for DEFINE, Routines 3, 5 and 6).

Routine 4: Definition with Attribute Labeling. First the form class of the target word is identified along with a general statement of what a definition of this form class should consist of. Then a short form of the target word's definition is presented with the parts labeled according to the preceding statement.

Routine 5: Multiple Choice Paraphrase. In this routine part of a definition paraphrased from the original definition appears on the screen; it is incomplete because one of the critical attributes is left blank. The student selects from three choices the paraphrase of the missing critical attribute. Feedback for an incorrect response tells the student to pick again. This routine is repeated for the number of critical attributes contained in the target word.

In this routine an option is introduced. The definition from Routine 4 can be either present or absent while the multiple choice paraphrasing occurs in Routine 5. This and other options in other modules allow for variability in what we believe to be important instructional parameters. These options allow us to make some modules more similar or less similar to each other and to isolate parameters that theoretically might produce significant differences in achievement.

Routine 6: Multiple Choice Definition Construction. In this routine the general statement of the form of the definition (from Routine 4) is given. The student selects a correct paraphrase (different from those in Routine 5) for all of the parts of the definition. This routine thus begins to approximate definition construction. Feedback for an incorrect response directs the student to try again. After two incorrect responses, the correct definition is shown.

Routine 7: Definition Construction. In the final routine of this module the student is instructed to type a definition of the target word. She/he is cued to start by typing the target word and to phrase the definition appropriately for a word in its form class. After making the response, the student compares his or her definition with a presentation of the original definition.

The criterion test for this module is similar to Routine 7, definition construction, minus the feedback.

For the remaining modules only those routines that are different from the routines in the DEFINE module will be described.

Classify Module

Routine 3: Example/Non-example. After presenting the word and its pronunciation plus the definition, CLASSIFY next presents a situational example of the target word and a matching non-example that differs from the example on only one attribute. Example and non-examples are labeled and a question is asked which requires the student to attend to the presence of the attribute in the example and its absence in the non-example. The student responds by typing either EXAMPLE or NONEXAMPLE. Feedback for an incorrect response calls attention to the attribute the student should have attended to in making the response, then directs the student to choose again. This routine repeats for each attribute of the target word then a final pair is presented which varies all attributes at once. (Figure 1 presents screen displays for CLASSIFY routines 3, 4 and 6).

Routine 4: Forced Choice of Example. Next a matched example/non-example pair of situations is presented unlabeled. The student is instructed that only one of the instances is an example of the target word and is asked to identify it by typing its number. Feedback indicates whether the response is correct or not and if not, the specific wording in the example that "gives it away" as the example is capitalized. The student chooses again. Note that in both Routines 3 and 4 the student must make the correct response before receiving the next item. This routine is repeated until a total of six or seven example/non-example pairs have been presented in both Routines 3 and 4.

Routine 5: Forced Choice Example Summary. This routine re-presents only the examples from the previous routine. They are identified as examples and the student is instructed to note how they are alike and how they differ.

Option: The short form of the definition can remain on the screen during Routines 3, 4 and 5. Having the definition on makes this module more similar to DEFINE.

Routine 6: Practice. In the final routine the student is presented with one instance at a time with the direction to type the target word if the instance is an example or type "Not (target word)" if it is a non-example. This routine is repeated four times with the instances being randomly varied between examples and non-examples with the constraint that at least one example and non-example shall appear among the four instances. Feedback for an incorrect response labels the given instance as either EXAMPLE or NONEXAMPLE and presents the matching instance. The student is directed to read and compare the two instances. This routine re-presents missed items after all items have been presented once.

The criterion test for this module is similar to Routine 6, minus the feedback and the re-presenting feature.

Discover Module

This is a discovery version of CLASSIFY, the rationale being that a task requiring the student to induce a concept from examples might aid in the development of the critical attributes in memory. The routines are largely the same as in CLASSIFY but there are two important differences. First, the definition is not presented until the end in DISCOVER. Second, in place of CLASSIFY'S inquisitory example/non-example routine, DISCOVER has an expository Introductory Examples routine which simply presents a labeled, matched pair without calling attention to the critical attributes in the example.

The DISCOVER module then goes into the Forced Choice of Example routine, identical to that in CLASSIFY, and then into the Practice routine.

Options: The example/non-example pair from the Introductory Example routine and those pairs from the Forced Choice of Examples routine can remain on the screen throughout the latter routine. If this option is chosen, then the Practice routine is identical to Practice in CLASSIFY (the examples having been erased from the screen). If the option is not chosen then Practice takes a slightly different form. Instead of presenting only four instances to be classified and reserving their matching instances for feedback, the matching instances are included in the instance pool, thus giving four example/non-example pairs, randomly arranged. Feedback for an incorrect answer simply indicates that the answer is wrong and directs the student to try again.

The final routine presents the short version of the definition with attributes labeled.

The criterion test is the same as for CLASSIFY.

Word Relations Module

This module begins with the pronunciation and definition routines described earlier. The third routine, Forced paraphrase, is similar to the Multiple Choice Paraphrase routine in DEFINE except that instead of paraphrasing each separate attribute a paraphrase of the target word is selected. (Figure

2 presents screen displays for WORD RELATIONS Routines 3, 5 and 6).

The characteristic routines for this module begin with Routine 5, Explanation of Relations. This routine illustrates how two words can be related to each other by presenting two examples of a particular relation. The first example is an archetype of the relation, e.g., "Helpfulness is a QUALITY of a Boy Scout." The second example illustrates the same relation for the target word, e.g., "Insincerity is a QUALITY of a sycophant." The student is then directed to select another word that bears the same relation to the target word. This routine is repeated for three or four different relations. Feedback identifies the response as correct or incorrect and if incorrect, the student is directed to try again.

Option: The short form of the definition can remain on the screen during Routines 3 and 5.

In Routine 6 a word is presented along with the target word and the student selects the name of the relation between the two words. This routine continues through several examples for each of several relations, different ones from those used in Routine 5. In writing instructional materials for this module we work from a list of 15 possible relations. The list includes, for example: CAUSE of, RESULT of, TOOL of, TARGET of, LOCATION of, PART of, etc. Not all the relations are applicable to each target word, of course, but for those that apply four or five examples of each relation are written. This routine repeats for about 20 questions, presenting 2 to 4 questions for each appropriate relation. Feedback for an incorrect response identifies the answer as wrong and directs the student to try again. Missed items are re-presented at the end of the series.

The final routine, Relation Summary, lists all the relations taught for the particular target word and re-presents an example of each relation. The student is required to type the target word several times in this routine.

The criterion test is similar to Routine 6, minus feedback. Because this test is based upon a model of memory, we consider it to be experimental in nature. It will be of great interest to us to determine whether a subject receiving instruction solely via WORD RELATIONS will reflect a difference in cognitive structure from those subjects receiving instruction via the other modules.

Word in Context

The characteristic routines in this module present a story of about 160 words and a series of six or seven questions which relate details of the story to attributes or the target word (see Figure 2). The target word appears in the story only once, toward the end. The stories are often generated from one of the examples from CLASSIFY. As an aid in generating the questions Stein and Glenn's (1977) schema for analyzing story comprehension (derived from Rumelhart) served as a guide in selecting those units of a story that are most likely to be remembered.

The questions vary in format: multiple choice, yes/no and short answer. Feedback for an incorrect response identifies the answer as wrong and directs the student to try again.

Option: The story can remain on the screen while the questions are presented. If this option is chosen, feedback for an incorrect response also includes underlining the pertinent words of the story.

The last question presented is in the form of a multiple choice sentence completion. This approximates the terminal task of the module.

The final routine requires the student to finish a sentence, the given part of which includes the target word. The student response calls for an explanation of the word. For example, "A student might be called a sycophant if he . . ."

The criterion test for this module is sentence completion.

Word Line Module

This module is identical to WORD RELATIONS for the first four routines. The first new routine for this module, Routine 5 Illustrative Line, introduces the student to a word line, demonstrates how it is used and gives the student brief practice on the task that will follow. After having done this routine once, the student has the option of skipping it the next time he/she works through this module. (Figure 3 presents screen displays for WORD LINE Routines 5, 6, 7 and 8).

In Routine 6, Map Line, the word line presents the target word in a group with five other words of the same form class and requires the student to arrange them along the line according to some semantic dimension (usually the major attribute of the target word drawn from the definition). In Figure 3, for example, the dimension of the word line is: to make larger/to make smaller, for the target word "augment." The other words in the group include one synonym of the target word, two antonyms and two words that fall into the middle ground along the given dimension. Note that the instructions avoid implying that the word line represents a continuum with subtle gradations. The task essentially requires the students to sort six words into three categories; in this case, the categories are to make smaller, to make larger and to do something that neither makes smaller nor larger. Two words go into each category and the position of the words within categories is not important. Feedback identifies the response as correct or incorrect and places the word on the appropriate section of the line.

In Routine 7, Rate Line, the student is given a short word line with the target word and one other word in each category in position on the line. Six instances are presented and the student must select their appropriate positions on the line, thus relating an instance to a word on the line.

In Routine 8, the final routine, questions are asked and the student responds with the words from the word line. This provides two opportunities for the student to write the target word (plus the earlier opportunity in the Type from Memory routine). The criterion test for WORD LINE is similar to Routine 6, the student arranges the target word and five other words on a line.

Equivalents Module

The Equivalents module is a very simple comparison module. It consists of a single routine which presents repeated practice on items missed on the multiple choice pretest. The format is the same as on the pretest except for feedback. Confirmation is given following a correct response; in case of a wrong response, the correct answer is identified. Items continue to be re-presented until the student has responded correctly a given number of consecutive times. The option for this module is that the number of consecutive correct answers required may vary. An important feature of this module is the use of an item presentation strategy that attempts to maintain a lag of three interpolated items between a word's $n^{\underline{th}}$ and $(n + 1)^{\underline{st}}$ presentation.

Figure 4 illustrates the computer management of the instructional system. The left column (Input) refers to the various computer programs that process the instructional material for presentation to the student on the DECscope. The output program collects and prints out the student response data. The Student Use Package refers to the programs that test the student and present the words missed on the pretest for instruction via one or more modules.

There will eventually be two modes of system use: Instructional and Experimental. At present we are in the Experimental mode. In this mode the experimenter specifies how many words the student will learn and which module or modules will be needed for instruction. Later, in the instructional mode, prescriptions specifying combinations of modules will be developed from the experimental findings and tested for optimum achievement.

The Computer System

The vocabulary instruction is coded in Fortran IV and will be delivered via Digital Model VT-52 Video Display terminals with a 120 character/sec. transmission rate, connected to a PDP-15. The time-sharing system, ETSS, was developed at the Learning Research and Development Center (Fitzhugh, 1973). The system consists of a DEC PDP-15 computer, over 100 megabytes of high speed disk memory, and a terminal controller capable of supporting up to 32 work sites. In addition, a small DEC PDP-11 computer is attached to the PDP-15 and controls a high speed line printer, a card reader and a card punch. An on-line text editor, a comprehensive statistical package and a variety of utility systems are also provided. Several applications programers develop the instructional programs according to the specifications of the instructional designers.

Since our CAI programs are not yet completed, the studies we report were conducted with paper and pencil materials. In the second study we attempted to achieve as much moment-to-moment control over student learning processes as was possible within the constraints of a relatively inflexible paper and pencil media.

Two Vocabulary Studies

Two studies were conducted in pursuit of determining the instructional effects of several modules.

Study I

The first study (Rosner, 1978) used materials and a procedure directly modeled upon the 1966 study noted previously that served as our initial empirical justification for the existence of indirect effects from vocabulary instructional strategies. The purpose of Rosner's study was in part to determine whether the sizeable indirect effects found with the use of a definitions method could be replicated in our laboratory. She taught four difficult vocabulary words that were identified on the basis of a pilot study and word frequency counts to college students. Unfortunately, despite the fact that the difference between the number of words her instructional groups mastered compared to her control group was comparable to the difference between instruction and control groups in the 1966 study, her difference was not significant. Thus, it was not meaningful to discuss the effects obtained via the instruction.

We suspect that most of the difficulties of the study were procedural. First, students in the 1966 study kept the materials for 12 minutes; Rosner's students paced themselves for an average of 7 minutes with the material. Recent research on learning within CAI or CMI environments has shown that problems students encounter center around deficiencies in self-management skills (see Judd, McCombs & Dobrovolny, 1978) and they need skill management training. It seems likely, therefore, that students simply did not manage their word study effectively. A second problem is concerned with defining an appropriate degree of control over student learning processes when only a single frame is devoted to a particular word (as was the case in the 1966 study for the definitions method). This level of instructional control over student learning processes is fairly gross; students can make the single required response for each instructional word, then attention can wander for the rest of the interval (in some students) or appropriate study behavior will take place (in others). Perhaps it is the case that the naturally occurring distribution of learner processes during a "free" period is the significant determiner of achievement and not instructional method (at least as such methods were implemented in the 1966 study). Since Rosner's learners spent a briefer time in instruction than those in the 1966 study, it is possible that had more time been required (or multiple frames per word been used) achievement might have been increased. Finally, the lack of significant differences may have been due to a higher level of prior learning of the instructional words than was expected.

We improved the methodology of the second study by using multiple frames to instruct a word and the frames were modeled after two of our CAI modules. This change had the effect of increasing instructional time and theoretically, achieved more precise control over student learning processes within a given instructional interval. We also used a pretest as a method for identifying previously unknown instructional words. Thus, our second study is modeled as closely after our instructional system design as we could accomplish within the constraints of paper and pencil materials. A second constraint was that we had to use a fixed number of instructional sessions because our subjects were recruited from a small educational psychology class.

Study II

Purpose. The major purpose of the study was simply to verify the existence of indirect effects under the instructional conditions we had designed. The modules tested were those for which material had been written and tested, the DEFINE module and the CLASSIFY module (in adapted paper and pencil form). In the paper and pencil adaptation, we used all of the instructional routines that defined each module, adapted as best we could to a paper and pencil PI-type format. The instructional materials consisted of a series of frames for each word that followed a shaping procedure.

Design and Procedure. Ten infrequent words were taught to two groups of students recruited from an introductory educational psychology class. There were 12 students randomly assigned to the two instructional groups. The materials for each instructional word consisted of five pages of instructional frames with response feedback typically at the top of a "next" page. Students also had to use a paper cover, laminated plastic sheets designed to be used to cover up certain portions of the previous text material. The paper cover was our attempt to mimic the erasure capability of a CRT. The words were presented in a different random order to the students.

In the first session, students took a multiple choice pretest requiring identification of a verbal phrase equivalent in meaning, learned the ten words (some of which they already knew as indicated by the pretest), and then took an immediate definitions posttest. It was not possible given constraints under which the study operated to teach students only the words they missed. Students returned exactly one week later for retention tests (they were not informed they would be tested). They were given six tests - free recall, definition-stating, sentence generation, sentence understanding, classification; the multiple choice pretest also served as a posttest. The free recall test was included because we believe modules other than the ones used in the present study will influence free recall, and we wanted a measure from the two methods of interest in this study. The tests were ordered as noted to mimimize learning from one test to the next.

Results and Discussion

Time and Total Learning. There was a significant difference in the mean amount of time spent learning in the two groups. Mean time spent in Define instruction was slightly longer ($\bar{X}$ = 29.4 minutes) than in Classify instruction ($\bar{X}$ = 25.7 minutes) a difference of 3.7 minutes. We do not, however, think the time difference is large enough to be practically significant or to strongly bias our achievement results. Our mean time per word was close to the 1966 study which used 12 minutes for 4 words.

The two groups did not differ in prior level of word knowledge when entering the instructional treatments; the Define group knew an average of 6.7 words, while the Classify group knew an average of 5.8 words ($t = 1.25$, $df = 22$, $p > .05$). A t test of the mean number of words gained in each group using scores on the multiple choice test that was given as a pre and posttest showed both groups gained an equivalent amount ($\bar{X}$ gain for Define was 2.67; $\bar{X}$ gain for Classify was 3.10; $t = 2.074$, $df = 22$, $p > .05$). A comparison of scores on the immediate definitions test with the delayed definitions test (see scoring system below) revealed higher average immediate scores for both groups and no significant difference between the two groups in proportion of new words learned, then forgotten ($t = .549$, $df = 22$, $p > .05$). There were no differences in the number of instructional words that were recalled in the free recall test ($\bar{X}$ for Define was 4.0; $\bar{X}$ for Classify was 3.9; $t = .108$, $df = 22$). These data are decidedly consistent with the proposition that in terms of total amount of achievement, type of instructional method does not make a difference.

Indirect Effects

The concepts of direct and indirect effects require that we consider instructional methods not only in terms of contribution to a single outcome of interest but in terms of patterns of achievement across multiple objectives that might be desired as outcomes of an instructional program. Tables 2 and 3 show the mean performance on several criterion tests of the instructional objectives as a function of instructional method (the sentence understanding test is not included as we have not arrived at a reliable scoring system yet). The data are presented for all instructional words (Table 2) and for only those words learned in the course of the instruction (the "new" words [Table 3]).

The total number of points that could be earned varied from one criterion test to another. The definitions posttest was scored 0, 1, 2 depending on number of attributes mentioned in a definition (reliability = .90; maximum points = 12x10x2 = 240); the classification

TABLE 2

Mean Performance on Several Criterion Tests of the Instructional Objectives.
The Proportions in Parenthesis are the Comparable Figures from the 1966 Study

ALL WORDS

Method Group	Number of Subjects	Number of Words	Define			Classify			Sentence Generation		
			pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$
Define	12	10	167	240	.696 (.631)	841	960	.876 (.875)	255	360	.708 (.718)
Classify	12	10	117	240	.487 (.668)	843	960	.878 (.887)	219	360	.608 (.756)

NOTE: pts. obt. is points obtained
pts. poss. is points possible

TABLE 3

Mean Performance on Several Criterion Tests of the Instructional Objectives

NEW WORDS ONLY

Method Group	Number of Subjects	Number of Words	Define			Classify			Sentence Generation		
			pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$
Define	12	40	44	80	.550	288	320	.900	70	120	.583
Classify	12	50	35	100	.350	357	400	.892	64	150	.427

NOTE: pts. obt. is points obtained
pts. poss. is points possible

test comprised 8 instances per word (maximum points = 12x10x8 = 960); the sentence generation test was scored 0, 1, 2, 3 depending on meaning and usage (reliability = .90; maximum points = 12x10x3 = 360). The data for all words in the Define group are clearly comparable to the 1966 study; there are, however, some discrepancies in the Classify group. The discrepancy in the sentencing test is easily explained; our test required complete sentence construction (using the word "because") whereas the 1966 study required sentence completion (a meaningful stem was given). There were procedural differences in concept teaching methods between the 1966 study and ours which is probably responsible for our classify students lower defining performance. The data for new words only show lowered performance on the defining and sentencing tests as would be expected for words that students have no prior knowledge of. The pattern of levels of achievement shown for all words is reflected in the new words only for the defining and sentence generating tests. The classification test retains a high level of performance because it is an easier test. A test of the largest achievement difference (Define vs. Classify for all words) revealed no significant differences: $t = 2.006$, $df = 22$, $p > .05$. We are tempted to conclude, as was done in the 1966 study, that transfer from one instructional method to tests based on other methods is 100% and therefore we have evidence of substantial indirect effects.

Within a CAI context, however, it is standard procedure to define criteria that individuals must meet before they can exit a particular segment of instruction. Both studies, ours and the 1966 study, fixed the amount of time and material to be covered within an instructional treatment, and did not set a mastery criterion. Therefore, in order to study the indirect effects that may be associated with a particular instructional strategy, we must assess those effects contingent upon a performance standard.

Tables 4 and 5 show the quality of performance on the several criterion tests as a function of the quality of performance on the criterion test matched to the instructional method. In each instructional group for each new word and each student, the occasions on which the posttest score was excellent (a score of 2 for the definitions post; a score of 7 or 8 instances classified correctly out of 8 instances) and the occasions on which

TABLE 4

Quality of Performance on the Classification and Sentence Generation Posttests as a Function of Quality of Performance on the Definitions Posttest for the DEFINE Instructional Group.

	Type of Performance on Define Post		Type of Performance on Other Posts			
			Classify		Sentence Generation	
	Number of Subjects	Frequency	Good	p	Good	p
Good	8	18	18	1.0	16	.89
Poor	5	14	8	.57	3	.21

TABLE 5

Quality of Performance on the Definitions and Sentence Generation Posttests as a Function of Quality of Performance on the Classify Posttest for the CLASSIFY Instructional Group.

	Type of Performance on Classify Post		Type of Performance on Other Posts			
			Define		Sentence Generation	
	Number of Subjects	Frequency	Good	p	Good	p
Good	12	38	10	.27	16	.42
Poor	7	12	2	.16	2	.16

it was poor (a score of 0 for the definitions post; a score of less than 7 instances classified correctly) were noted. For these two classes, observations of the quality of performance of the same student on the same word were made on the other posttests. For example, in Table 4, of the 18 observations of high quality definitions, there were 18 observations of high quality classification performance and 16 observations of high quality (a score of 3) sentence generation. It can be easily seen from a comparison of Tables 4 and 5 that the consistency in the quality of performance from a defining post (Table 4) is quite different from a classifying post (Table 5). The trends evident in the tables tend to show that Define instruction leads to more indirect effects than Classify instruction, for high quality performances tend to be maintained to a greater degree. However, a test of the significance of the difference in the proportions using the normal approximation to the Irwin-Fisher exact test showed no significant differences ($X^2 = 2.39$, df = 3, $p > .05$). We do however believe the trends suggest different sized indirect effects, and we shall continue to pursue them in the manner we have outlined.

We have, therefore, decided that within a CAI context it is more appropriate to assess indirect effects under conditions of instructional treatments with predefined proficiency levels rather than conditions defined in terms of a fixed amount of time or number of items. This does not negate the formulation presented previously. What we have done is to clarify the definition of indirect effects in a criterion referenced (rather than norm referenced) context. The design of our CAI system reflects this clarification: We have incorporated an interim test for each module (see Figure 4) whose format is matched to the module. Students cannot exit from a given module until the interim test is passed.

Future Work

In the near future, our research will concentrate on testing for indirect effects and testing predictions from our model, such as theorem number 7 mentioned previously. Our goal is to develop the prescriptive rules that allow us, through suitable selection of instructional strategies, to optimize a given performance function across a variety of criterion tests, within certain time constraints. As we perform our research we will, of course, be providing services to developmental reading laboratories and we are anxious to begin implementation at our planned sites.

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Rosner, C. *The definitions method of teaching vocabulary: Two levels of processing.* Unpublished master's thesis. Pittsburgh: University of Pittsburgh, Learning Research and Development Center, 1978.

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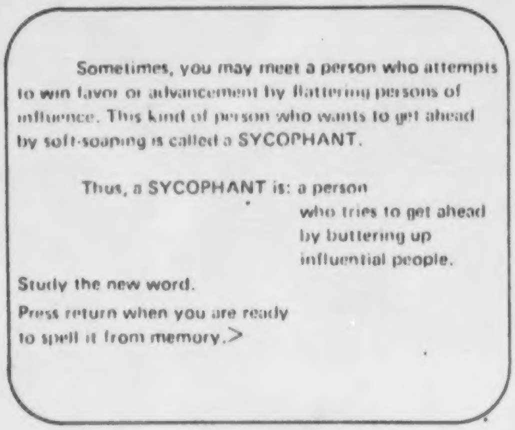
DEFINE

Routine 3: Type word from memory



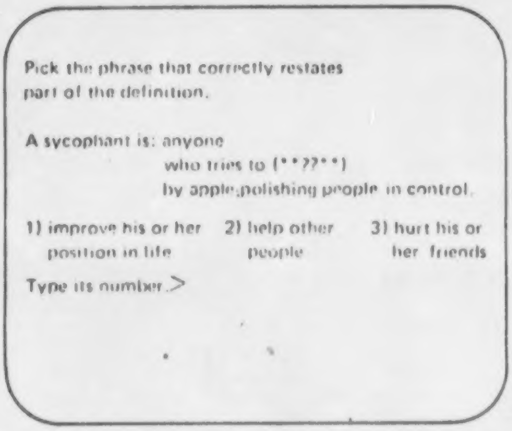
Sometimes, you may meet a person who attempts to win favor or advancement by flattering persons of influence. This kind of person who wants to get ahead by soft-soaping is called a SYCOPHANT.

Thus, a SYCOPHANT is: a person
who tries to get ahead
by buttering up
influential people.

Study the new word.

Press return when you are ready
to spell it from memory. >

Routine 5: Multiply choice paraphrase of each of the definition's critical attributes



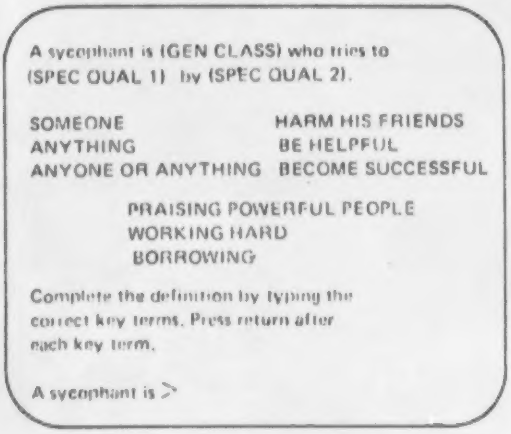
Pick the phrase that correctly restates
part of the definition.

A sycophant is: anyone
who tries to (**??**)
by apple-polishing people in control.

1) improve his or her position in life
2) help other people
3) hurt his or her friends

Type its number. >

Routine 6: Multiple choice paraphrase of all critical attributes



A sycophant is (GEN CLASS) who tries to
(SPEC QUAL 1) by (SPEC QUAL 2).

SOMEONE
ANYTHING
ANYONE OR ANYTHING

HARM HIS FRIENDS
BE HELPFUL
BECOME SUCCESSFUL

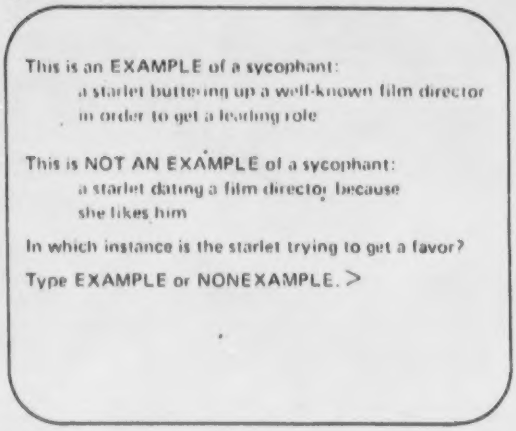
PRAISING POWERFUL PEOPLE
WORKING HARD
BORROWING

Complete the definition by typing the
correct key terms. Press return after
each key term.

A sycophant is >

CLASSIFY

Routine 3: Matched Example and Non-example



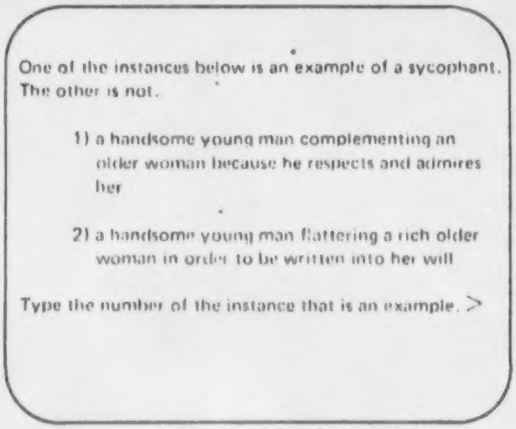
This is an EXAMPLE of a sycophant:
a starlet buttering up a well-known film director
in order to get a leading role

This is NOT AN EXAMPLE of a sycophant:
a starlet dating a film director because
she likes him

In which instance is the starlet trying to get a favor?

Type EXAMPLE or NONEXAMPLE. >

Routine 4: Forced choice of example



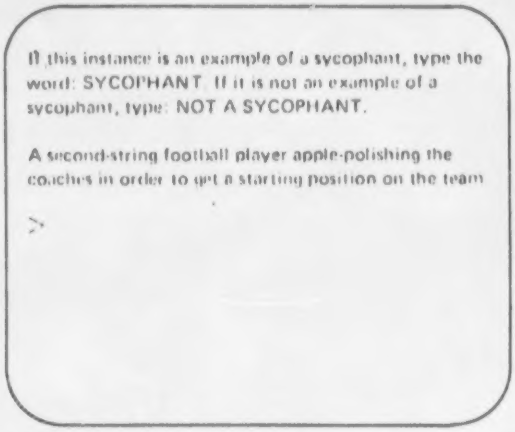
One of the instances below is an example of a sycophant.
The other is not.

1) a handsome young man complementing an older woman because he respects and admires her

2) a handsome young man flattering a rich older woman in order to be written into her will

Type the number of the instance that is an example. >

Routine 6. Practice



If this instance is an example of a sycophant, type the word: SYCOPHANT. If it is not an example of a sycophant, type: NOT A SYCOPHANT.

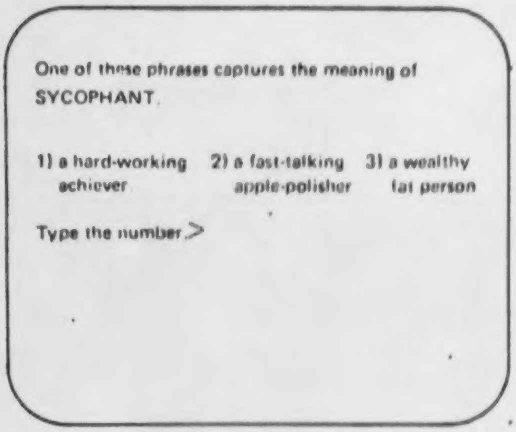
A second-string football player apple-polishing the coaches in order to get a starting position on the team

>

Figure 1. Simulated screen display for DEFINE and CLASSIFY.

WORD RELATIONS

Routine 3: Paraphrase

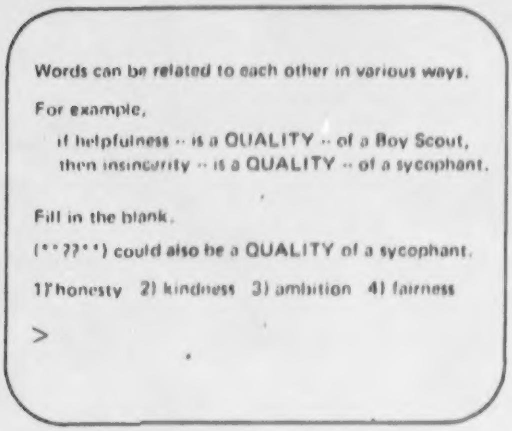


One of these phrases captures the meaning of SYCOPHANT.

1) a hard-working achiever 2) a fast-talking apple-polisher 3) a wealthy fat person

Type the number.>

Routine 5: Relations



Words can be related to each other in various ways.

For example,

if helpfulness -- is a QUALITY -- of a Boy Scout,
then insincerity -- is a QUALITY -- of a sycophant.

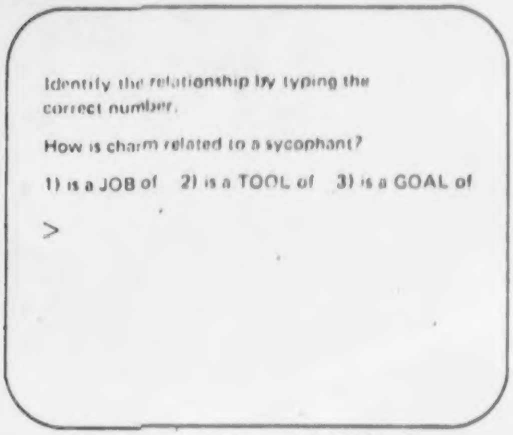
Fill in the blank.

(**??**) could also be a QUALITY of a sycophant.

1) honesty 2) kindness 3) ambition 4) fairness

>

Routine 6: Practice



Identify the relationship by typing the correct number.

How is charm related to a sycophant?

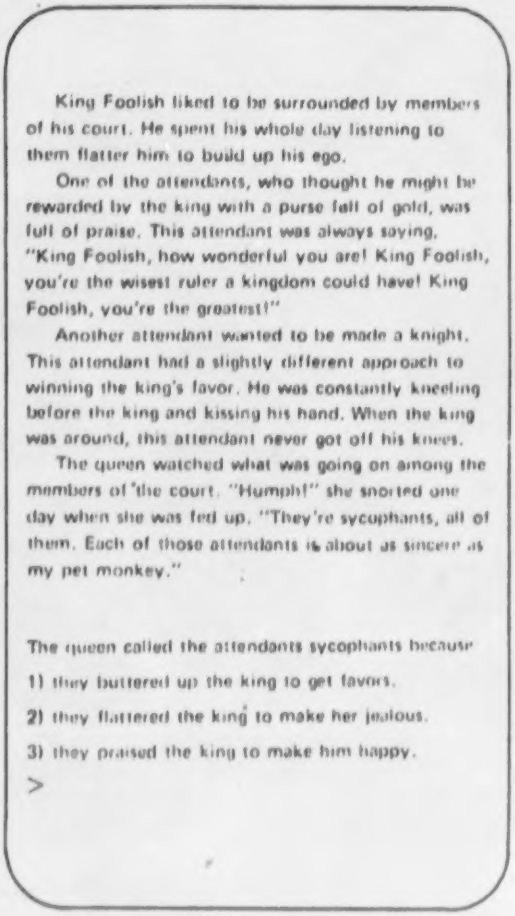
1) is a JOB of 2) is a TOOL of 3) is a GOAL of

>

Simulated DECscope screen display for WORD RELATIONS routines.

WORDS IN CONTEXT

Routine 4: Story and Questions



King Foolish liked to be surrounded by members of his court. He spent his whole day listening to them flatter him to build up his ego.

One of the attendants, who thought he might be rewarded by the king with a purse full of gold, was full of praise. This attendant was always saying, "King Foolish, how wonderful you are! King Foolish, you're the wisest ruler a kingdom could have! King Foolish, you're the greatest!"

Another attendant wanted to be made a knight. This attendant had a slightly different approach to winning the king's favor. He was constantly kneeling before the king and kissing his hand. When the king was around, this attendant never got off his knees.

The queen watched what was going on among the members of the court. "Humph!" she snorted one day when she was fed up. "They're sycophants, all of them. Each of those attendants is about as sincere as my pet monkey."

The queen called the attendants sycophants because

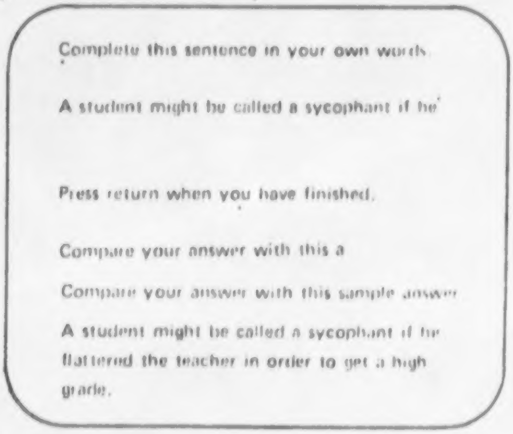
1) they buttered up the king to get favors.

2) they flattered the king to make her jealous.

3) they praised the king to make him happy.

>

Routine 8: Sentence Completion



Complete this sentence in your own words.

A student might be called a sycophant if he

Press return when you have finished.

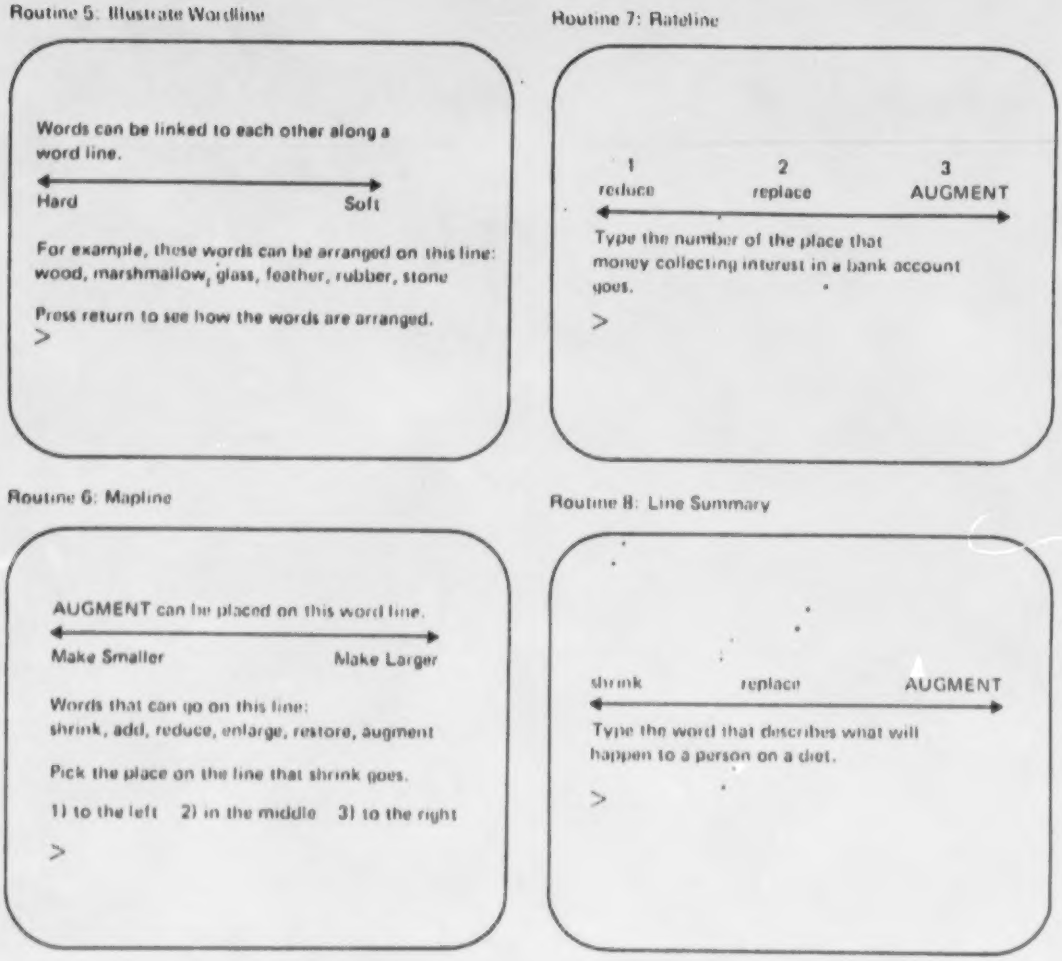
Compare your answer with this a

Compare your answer with this sample answer

A student might be called a sycophant if he flattered the teacher in order to get a high grade.

Figure 2. Simulated screen display for WORD RELATIONS and WORDS IN CONTEXT.

WORD LINE



Routine 5: Illustrate Wordline

Words can be linked to each other along a word line.

Hard
Soft

For example, these words can be arranged on this line: wood, marshmallow, glass, feather, rubber, stone

Press return to see how the words are arranged.

>

Routine 6: Mapline

AUGMENT can be placed on this word line.

Make Smaller
Make Larger

Words that can go on this line: shrink, add, reduce, enlarge, restore, augment

Pick the place on the line that shrink goes.

1) to the left 2) in the middle 3) to the right

>

Routine 7: Rateline

1
reduce
2
replace
3
AUGMENT

Type the number of the place that money collecting interest in a bank account goes.

>

Routine 8: Line Summary

shrink
replace
AUGMENT

Type the word that describes what will happen to a person on a diet.

>

Figure 3. Simulated screen display for WORDLINE.

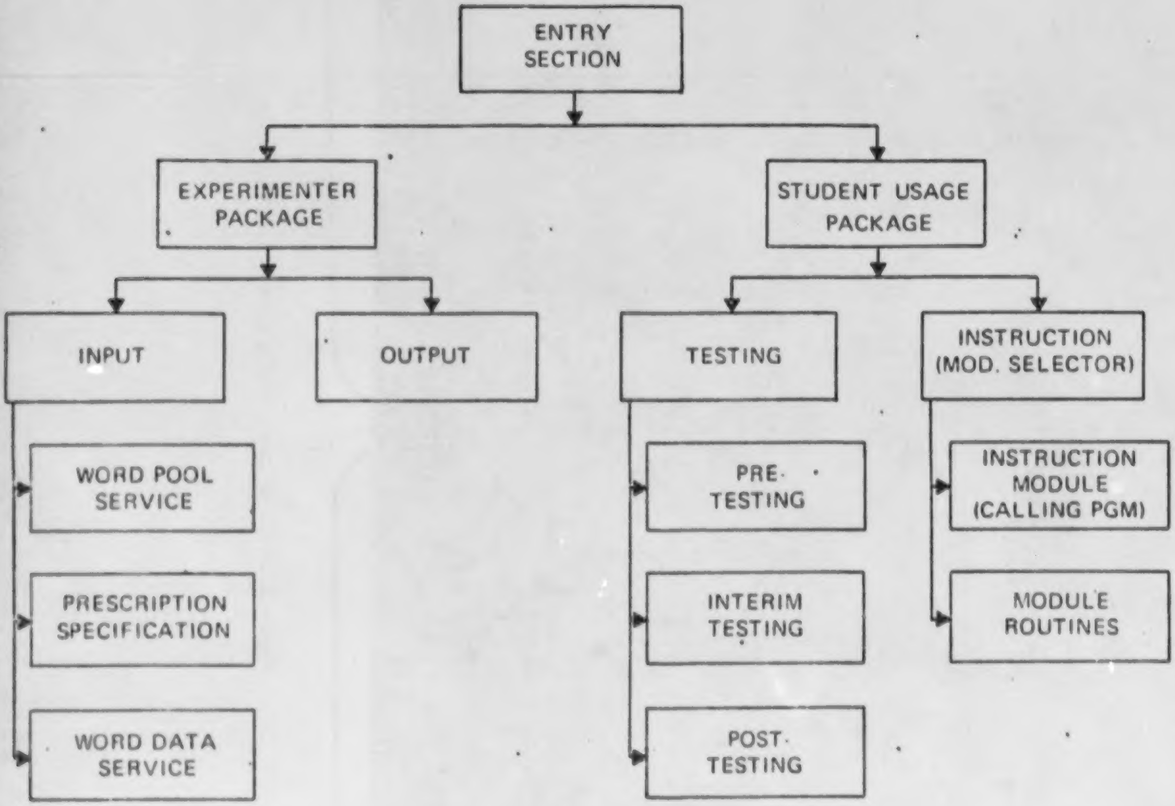

ENTRY SECTION
EXPERIMENTER PACKAGE
STUDENT USAGE PACKAGE
INPUT
OUTPUT
TESTING
INSTRUCTION (MOD. SELECTOR)
WORD POOL SERVICE
PRESCRIPTION SPECIFICATION
WORD DATA SERVICE
PRE-TESTING
INTERIM TESTING
POST-TESTING
INSTRUCTION MODULE (CALLING PGM)
MODULE ROUTINES

Figure 4. CAI Vocabulary Instructional System

The American High School Student and the Computer: A Survey of Attitudes

Justine C. Baker

University of Pennsylvania

An alternate title for this paper might be: "How Does the Computer Evaluate Its Instructional Performance in Some American High Schools?" More specifically, answers to the following questions, among others, are examined in this report. (1) Is the high-speed digital computer the superior instrument for solving complex mathematical problems? (2) Do computer-based learning activities, such as game playing and simulation experiments, represent the "fun" phase of the curriculum? Figuratively speaking, the computer is on trial. The computer's jury is a sample of high school students; its judge is, ironically, itself.

In the spring of 1978 I had to write a paper for a course in which I was enrolled at the Graduate School of Education of the University of Pennsylvania. Because of my interest in computers and their relation to education, I chose a topic closely entitled to that of this report.[1]

A sample of 74 students from Marple-Newtown Senior High School comprised the subject pool for the attitudinal survey. Their reactions to my questionnaire were coded on optical scanning sheets which were submitted subsequently to a computer system for statistical analysis. Fortunately, a canned program known as ITEMRS was available to perform the detailed, sophisticated analysis.[2]

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[1] This course was entitled "Introduction to Psychometric Theory." (That title has been changed to a more appropriate one--"Introduction to Personality and Attitude Measurement.") My instructor, Maria Watkins, offered valuable suggestions concerning the preparation of a questionnaire that served as the nucleus of my proposed topic.

About 2 weeks after my term paper was finished, along with the course, I received a notice concerning proposals for this Conference. Naturally I thought of extending the Marple-Newtown study to a new survey with more participants scattered over the United States.

Unfortunately, my ambition was not fully realized, for subjects proved quite difficult to acquire. Notwithstanding the obstacles, both in conducting the research and in managing the budget, I succeeded in completing a second study.[3] This survey took place in the fall of 1978. A new sample, this time consisting of 225 students from six school districts, served as subjects. Their valuable responses, to basically the same questionnaire that the first group had used, were coded on optical scanning sheets and submitted to an IBM 370/168 model computer which stores the ITEMRS package. After analyzing the data pertinent to this study, I found comparisons and contrasts with the former project. Hereafter, the Marple-Newtown study will be cited as the "pilot survey"; while the latter study will be cited as the "principal study."

Pilot Survey

Method

Subjects. Seventy-four students from six classes at Marple-Newtown Senior High School participated.[4] Classes were selected rather than individual students because of the instructional use of the computer in those classes and because of the willingness of the teachers to cooperate.[5] Five were math classes; one was a business class. Respective course titles were "Computer Mathematics I" and "Concepts of Data Processing." There were 17 students from the business course, all of whom were female. From the math classes, not quite half of the participants were female. In all, approximately 40 females and 34 males served as respondents.[6] With respect to age, 17 was the average, for the vast majority of subjects were in 11th or 12th grades. More than half, however, were seniors.

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[2] ITEMRS (pronounced "Item Mars") was written mostly in FORTRAN by Dr. Daniel Ashler for use at the Center for Research in Evaluation and Measurement, University of Pennsylvania. CREM operates under the capable direction of Dr. Andrew R. Baggaley of the Graduate Education Faculty.

[3] This survey was largely self-financed. Nonetheless, a small contribution, through the benevolent office of Dean Dell Hymes of the Graduate School of Education, has helped decrease overall expenditures.

Many of the subjects were taking a computer course for the first time, at least in a public school environment. As might be expected, the subjects in the computer math classes had stronger backgrounds in abstract mathematics than those in the computer business class. Many of the math students were taking either an algebra II class or a calculus class concurrently. There was one student, however, who was enrolled in both computer math and computer business. She answered the questionnaire only in her business class.

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[4] The Marple-Newtown School System is located in the neighboring communities of Broomall and Newtown Square, Pa. Both suburbs are inhabited largely by middle to upper-middle class families.

[5] Professional educators who helped with this survey were Dr. Vincent Sauers, Assistant Superintendent (now superintendent at Penn-Delco School District), Faye Lewis, Mathematics Department Chairperson, and math teachers (also proctors) Donald Ash and George Mayer. Joyce Bresee, Business Department Chairperson, also served as a proctor for her class.

[6] This male-female breakdown was reached through conversations with the teachers. Since this project was made primarily for attitude collection, no attempt was made to have students identify themselves by name or gender. In fact, student participation was strictly on an optional basis.

Besides being divided in general by differences in their mathematics curriculum, the two groups of subjects were differentiated by the kind of computer equipment to which they had access. Math students used two General Electric TermiNet hard-copy terminals. Business students used one IBM 5100 portable computer (with a video screen) and an IBM keypunch machine.

At the time the survey was taken, at the end of April in 1978, the math students had learned BASIC and were working on their term projects. Some of the projects involved the computer as a mathematical problem solver; others involved the computer in game playing and simulation. For example, among the latter group of programs were those featuring horse racing, football, lunar landings, black jack, and tic-tac-toe. By survey time, then, the math students were well acquainted with the computer. On the other hand, the business students had experienced keypunching. They also had used the IBM 5100 computer to solve a payroll problem in BASIC. Hence, by survey time these students, too, had a reasonable idea of the joy (maybe the frustration) of interacting with the electronic wonder.

Survey Instrument. For gathering information, a home-made questionnaire featuring 24 questions, was used. To add variety and to decrease monotony, some questions were written in a "pro-computer" context; others, in a "con-computer" context. Table 1 shows the questionnaire. Fundamentally, this cadre of items thrusts the student into reflecting on the computer in its relation to the school and also to society. The questions exhibited, however, are in the order used for the principal survey. Table 2 shows the adjustment in the second column from the left, which is headed "Corr. (corresponds) to Table 1 No. (number)." For example, item 1, that the sample from Marple-Newtown saw, is item 24 appearing in the list of questions in Table 1.

In regard to measurement, the Likert-type scale was fitted with weights. For items favorable to the computer, responses were weighted, 2,1,0,-1,-2 corresponding with Strongly Agree to Strongly Disagree, respectively. For items unfavorable to the computer, responses were weighted -2,-1,0,1,2 corresponding with Strongly Agree to Strongly Disagree, respectively. The former group are marked P, for positive first, in column three headed Wt. (weight) of Table 2. The latter group are marked N, for negative first, in that same column of Table 2. Given such a weighting system, recorded scores could theoretically range from 48 (for the "computernik") to a -48 (for the avid avenger).

Procedure. Questionnaires and optical scanning sheets were personally delivered to the educators who helped with the survey at Marple-Newtown. See footnote 5. The three teachers who served as proctors then distributed the materials during convenient class periods. On the average about 25 minutes out a 45 minute class period was needed for students to complete the survey. Completed answer sheets and questionnaires were personally retrieved about 2 weeks thereafter.

With respect to the actual completion of the survey, a cover page on the questionnaire provided directions to each student. This direction page cited how students were to fill in preliminary information as well as main responses on the answer sheets. In addition to printing name and/or social security number, each student participating in a math class was requested to mark 1 as a special code. Each business student was requested to mark 2 as a special code. (The codes will be discussed in the results section.) While the agree-disagree group in the response selection set was self-explanatory, the neutral option was singled out for explanation. Students were instructed to mark the neutral option in case of a "middle-of-the-road" feeling. Students were instructed to leave an answer blank if they had no opinion whatsoever.[7] Furthermore, students were told that their individual opinions would be kept confidential (in case they chose to identify themselves by name) and that their opinions would in no way affect their course grades. Students were also given the option to terminate their responses at any time before they reached item 24, the last question of the instrument.[8]

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[7] The computer, however, treated omitted responses in the same fashion as neutral responses--it assigned 0 weight to both categories.

In regard to the overall testing session, the following assumptions were made: (1) each student answered each statement honestly; (2) each student answered according to his/her own convictions (i.e., was not influenced by another student(s) in the class); (3) each student marked all choices correctly (i.e., there were no misplaced marks due to haste to finish or to questionnaire fatigue).

Results. Table 2 presents a digest by item analysis of data computed from the Marple-Newtown input. The statistics shown are thought to be the most germane to response interpretation. Four column headings of Table 2, however, need explanation. These headings are *Alpha-X* (read Alpha minus X), *Var*, *Corel*, and *Val*. *Alpha-X* is a reliability estimate of the test with the given item deleted. It is based on Cronbach's alpha reliability coefficient. *Var* is item variance, a measure of the number of distinctions a particular item makes among examinees. *Corel* is the product-moment correlation of item score with total test score, both of which are summed over examinees. It is based on Pearson's correlation coefficient. *Val* is the same as the product-moment correlation, but instead of correlating item score with total test score (both treated as continuous variables), the *Val* formula correlates item score with the special code, a dichotomous categorical variable known as the external criterion.

Recall that the math students marked their answer sheets with 1's; whereas, the business students marked their op scan forms with 2's. These codes were used to ascertain differences in preference between the two groups. Each datum in the *Val* column can be checked for significance in a standard table of correlation values. Given 70 degrees of freedom and 2 variables, the correlation coefficients .233 at the .05 level and .302 at the .01 level are significant in regard to a two-tailed test. With this guide and Table 2, numbers 5, 8, 17, and 19 can be siphoned out of the pack. To see what these items were, look at numbers 7, 3, 11, and 9 in that order in Table 1. These were the items that differentiated the math group from the business group. Stated in another way, the responses attached to those items were contingent upon group membership. (A test based on dominance in number of one group over another, however, is not quite as powerful as a test based on groups about equally divided.)

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[8] Some students, approximately 15, in the math classes did take advantage of this option and did not participate in the survey. The 74 students who did participate, read and for the most part responded to all 24 survey items.

It can be noted parenthetically that all Val coefficients would have been reversed in sign, but would have maintained the same absolute value, had the math students been coded as 2's and the business students as 1's. Regardless of the selection in weighting, the two-tailed test has made the sign accommodation.

Table 3 shows the frequencies of responses per choice for each item in the test. Hence, the answers to many questions (see Table 1) can be answered through careful scrutiny of the highlighted tallies.

For a global view of the test statistics, see the upper portion of Table 6. Also Figure 1 depicts graphically the distribution of scores according to a rather elementary line-segment graph. This type of graph was chosen for illustration because it was the line-segment analogue of the discrete asterisk plot the computer printed out and because it was the most convenient to draw given the relatively wide spread of scores.

Discussion

Since the subjects who participated in the survey were not drawn randomly, results primarily are specific to Marple-Newtown High School. That is, solid inferences, based on attitudes expressed by this group of teenagers, cannot be made about the population of computer users in American high schools. Nonetheless, student preferences and trends can be observed from the data. Future studies, based on randomly selected samples, could very well corroborate results obtained here.

Perhaps the most interesting "global" statistic that has emerged is the low positive mean test score. In other words, this sample, on the average, was "luke-warm" to the computer. The standard deviation, however, reveals a rather large spread in scores, and hence, attitudes. The line-segment graph pictorially confirms the numeric data and clearly shows outliers at the extreme ends of the scale.

Overall, the test instrument was well constructed as can be seen by the relatively high reliability coefficients. Even more important, however, is the standard error of measurement, computed from the lambda 2 reliability estimate. When multiplied by 2.58 (based on the normal curve), the standard error of measurement yields a product of 11, rounded to the nearest whole number. This means that a score interpreter could be 99% confident that each student's true score lies within a tolerance of 11 points of his/her obtained score on this test. For example, the student who scored the highest "grade" on this test, namely a 34, could have scored as high as 45 or as low as 23. As a matter of fact, that student could have scored anywhere between these extremes, based on a circular neighborhood of 34, on any single application of this test or an equivalent thereof. But, the topic of test score theory is far beyond the scope of this paper.

Regarding specific items in the test, numbers 9 (19, Table 1) and 13 (12, Table 1) showed the highest correlation values, in that order. See Table 2. This means that a student's response to these questions is characteristic of his/her attitude toward the computer in the school (and to a certain extent in society) as witnessed by that student's total test score.

An explanation of items singled out as dependent upon math/business student status is interesting in light of the conditions surrounding these students at their school. Item 5 (7, Table 1) concerns simulation and game playing. Some of the math students had been involved with the computer in regard to this usage. On the other hand, the business students had no classroom experience with simulation/gaming programs. A majority of the business group, therefore, marked this item neutral. For item 17 (11, Table 1) math students felt handicapped because of limited time access to computer terminals. By assignment each student had about 10 minutes of computer time during school hours. The business students, however, had only completed one program. Many, in fact, worked in groups of two or three. Hence, these students did not feel as pressed for computer time as did the math students who had to turn in computer printouts of their individual projects for a course requirement.

Item 8 (3, Table 1) and 19 (9, Table 1) were also found to split the math/business group. An overwhelming majority took the strongly agree-agree options on item 8 (see Table 3). A probable explanation involves the "time press" felt by the math students. Given the 1 to 1 ratio of students to pocket calculators, the swing toward the little electronic gadgets and against the computer is understandable. Lastly, for item 19, in view of what has previously been said, it is clear that the math students typically reacted positively in their responses to this question.

In closing the discussion about the external criterion, it is interesting to note that the correlation between the total test score and the external criterion reached -.1570 (or .1570 if a reversal of code had been assigned). This low statistic states that, in regard to the test as a whole, there was no difference between the preferences of the math students as opposed to the business students.

The frequencies shown for items 6, 7, 8 and 14 in Table 3 reveal the answer to question 1, posed in the introduction. Although many students in the sample were either neutral or hostile to writing programs to solve math problems, the majority agreed that for complicated problems the computer was the best tool. They also saw the need for computers in today's technological world. Nonetheless, the students overwhelmingly felt that for the kinds of problems they encounter in the high school, the readily accessible pocket calculator beats the computer.

The answer to question 2 is manifested by the responses given to item 5 concerning simulation/gaming programs. Review Table 3. Some of the math students who had begun their term projects that involved these "fun" activities, apparently were responsible for the 35 who marked the favorable group.

Principal Survey

Method

Subjects. Two hundred and twenty-five students from 15 classes in 6 public senior high schools participated. Schools (and the number of subjects per school) represented in this study were: Hellgate High School in Missoula, Montana (12); Andover High School in Andover, Massachusetts (31); and four schools in suburban Philadelphia, Pennsylvania: Upper Darby (51), Radnor (29), Haverford (19), and Marple-Newtown (83).[9] As was the case in the first survey, students were drawn by classes. In effect, teachers volunteered their students as subjects.

With respect to demographic characteristics, the sample consisted of 159 males and 66 females. The modal age was 17, for 124 marked their ages as such. Five students were 14 or younger; 16, 15 years old; 67, 16; and 10, 18 or older. (Three subjects did not answer the age question.) Regarding the grade breakdown--142 were seniors; 63 juniors; 12 sophomores; and 3 freshmen. Two subjects claimed they were ungraded; three did not mark their grade levels. Regarding socioeconomic status--these students most likely came from middle to upper-middle class families. (This question, however, was not asked in the survey.)

All members of the sample were involved with computers through mathematics classes. Course titles varied: "Computer Math" (Marple-Newtown and Radnor), "Computer Concepts" (Haverford), "All Purpose Programming" (Upper Darby, 2 classes), "COBOL" (Upper Darby, 1 class), "Computers and Programming" (Andover), "Computer Programming (Hellgate), "Computer Probability" (Radnor, 1 class). With the exception of the latter two courses, all courses are presented over one semester. The computer course at Hellgate can extend to three semesters; the course at Radnor is a year course.

An overwhelming majority, 186 to be exact, stated they were taking a computer course for the first time at school. Twenty said their current course represented their second computer course. Fourteen students admitted to taking more than two computer courses; five failed to answer that question. Moreover, the vast majority of students said their computer course was selected on an optional rather than a mandatory basis. The former category included 208 subjects; the latter, 6 subjects. Eleven students appeared to be confused by the question.

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[9] Initially 24 school districts, known to utilize computers for instruction, in 16 states plus the District of Columbia were contacted. About 50 subjects from only 2 of the districts materialized. The four schools, near the University of Pennsylvania, were then contacted to increase sample size.

All students, except those in one class at Upper Darby and two classes at Haverford, studied BASIC. The class at Upper Darby worked with COBOL; the group at Haverford learned FORTRAN IV. The Radnor class, entitled "Computer Mathematics," was scheduled to study FORTRAN (after BASIC) toward the end of the semester.

In the way of computer equipment, the usual hard-copy and video-screen terminals prevailed. Numerous computer vendors supplied the hardware. In this list were: IBM, Xerox, Wang, DEC, NCR, GE (RCA), and Burroughs. For the interactive mode, the typical communication was between school terminal and large university computer. For the batch style, the teacher (Upper Darby) physically transported cards to a computer at a neighborhood college (Widener).

Survey Instrument. Table 1 shows the attitudinal questions to which the sample responded. Another set of questions, numbers 25 through 30, were added to tap demographic and course information. This latter group of items, assigned zero weights, did not enter into the total scores that were tallied as described in the pilot survey. Nonetheless, for correlational purposes, responses to these items were arbitrarily weighted and calculations were made in a subsequent computer run.

Procedure. A method similar to the pilot survey was employed.[10] Materials to distant schools, however, had to be sent and returned through first-class mail. Completed materials were collected during the month of October.

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[10] Professionals involved with this survey were: Kyle Boyce and Jim Heydon (proctors) from Hellgate; Douglas Walshe (proctor) from Andover; Dr. Marvin Jaffe, Principal, and Jim Stanfield and Steve Wessel (proctors) from Upper Darby; Barbara Swanson, Math Department Chairperson, and Frank Miller and Colin

In addition to questionnaires and op scan sheets for their students, teachers were given proctor sheets and survey forms. The former stressed teacher responsibilities, such as maintenance of a test-like atmosphere in the classroom during the response period. (The assumptions, stated in the pilot survey, were thereby considered in force.) The latter requested more specific information about participating classes.

About 30 minutes of class time was needed per student for completion of the survey. Students were not required to mark special codes for the external criterion. Classification codes were decided upon and marked on the answer sheets after the materials had been returned. The external criterion selected was: 1, for students in classes where they had little actual experience with programming and interaction with the computer; 2, for students in classes where they enjoyed moderate computing experience. (This coding provided a general distinction by class. This demarcation was not fine enough to take into account individual experiences with the computer in extracurricular activities.)

Results

Because of lack of randomness in subject selection, projections to the user population cannot accurately be made. Preferences, for the most part, are particular to subjects studying at survey schools. Tables 4 and 5 and the lower portion of Table 6 display statistics characteristic of this sample.

Note, especially, that Table 4 exhibits items 19 and 12 as those with the highest correlations to total test score. (Recall that in the pilot survey equivalent items 9 and 13, in matching order,showed the highest correlations with total test score.)

Val coefficients that show significance at the .01 level are linked to items 1, 12, 14, 17, and 19. Item 13 shows a significant external correlation at

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Connor (proctors) from Radnor; Dr. David Heckman, Superintendent of Administrative Services, and Kenneth Hair (proctor) from Haverford; Faye Lewis, Math Department Chairperson, and Donald Ash and George Mayer (proctors) from Marple-Newtown.

the .05 level. For these items, responses apparently were contingent, to a certain extent, on classroom computing time, measured approximately by the speed in which students were exposed to programming. Also the correlation between total test score and the external criterion reached significance at the .05 level. See Table 6. It should be noted that the criterion just about equally divided the groups. There were 108 1's and 117 2's.

Discoveries gleaned from the second computer run involving item intercorrelations showed the following. (1) Students' attitudes in this survey were influenced by neither gender nor age. (2) Answers to questions 12 and 19 were somewhat dependent on whether the student freely elected his/her computer course or whether the student was assigned to that course.

Discussion

In this concluding section, several observations need to be examined. First, the mean of this sample increased over that of the former group. Is this difference in means statistically significant? To answer this question, it was necessary to go beyond ITEMRS to a *t*-test (based on a formula found on p. 405 in Hays). The *t* value calculated, $t = -2.35$, turned out to be significant at the .01 level (according to normal probabilities). Basically this statistic implies that there *is* a difference in attitudes between the populations from which these samples were drawn. Why the second group was significantly more favorable to the computer than the first group is a topic for further research.

Second, a statistic known as W (in this program), not shown in Tables 2 and 4, can be used as a gauge of an item's discrimination power. Very high W's were computed for items 7 and 11; very low W's, for items 10 and 15. This means that students who scored relatively high in the test enjoyed writing game and simulation programs. The high scorers also wanted their schools to purchase additional computer equipment. On the other hand, high scorers reacted somewhat negatively to computer literacy courses for all high school students. Also among high scorers a negative trend toward conversing with the computer in English seemed evident. (Both items in the low W category can be distinguished as "hypothetical.")

Third, this group appears to be well motivated by game and simulation computer activities. A similar trend was noted in the first sample. Along the similarity line--these students also felt that for high school problems the pocket calculator was quite adequate; for involved and complicated problems the computer was essential. In addition, they showed that they understood the need for high-speed computers in society.

Therefore, aside from probability and statistics, there is no cogent reason to feel that these students are atypical from thousands of high school students engaging in computing activities across the country. Their resounding message indicates reinforcement.

In conclusion, I believe more research in this area is needed. Large research organizations, given time and money for detailed exploration and subsequent enlightenment, can best handle the task.[11] This study is just one small contribution toward that goal.

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[11] Personal communication--Donald Alderman of Educational Testing Service, Princeton, New Jersey. See April, 1978 *Educational Technology*.

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Table 1

Survey Instrument

How Do You Feel About Each of These Statements?

Give Your Own Honest Answers.

The same response set will be used from statements 1 through 24 of this instrument. Choose from:

(A) STRONGLY AGREE (B) AGREE (C) NEUTRAL

(D) DISAGREE (E) STRONGLY DISAGREE

1. I enjoy writing programs for the computer to solve mathematical kinds of problems.
2. I need a lot of tutoring (outside assistance) to write programs.
3. For solving high school problems, the hand-held calculator is easier to work with than the computer.
4. I would advise only my friends who are bright in math to take computer courses.
5. I would rather "converse" with a computer than do any other school activity.
6. I find writing programs for the computer very frustrating.
7. I enjoy writing game and simulation programs for the computer.
8. Every high school student should be required to take at least one computer course where she/he can get "hands-on" experience with computer equipment.
9. I get frustrated when the computer is "down" (not functioning) because I cannot work at the computer (terminal) to solve problems.
10. All high school students should take a computer literacy course, in which the computer's benefits to society are surveyed but no actual work with the computer is performed.

Table 1--Continued

11. My high school should purchase additional computer equipment.
12. I am sorry I took a computer course and will never again select such a course.
13. I want to major in computer science (serious study of computers and programming) in college and eventually work with computers.
14. I am happy when the computer is "down" (not functioning) because then I do not have to worry about interacting with the computer system.
15. Computers would be more fun to work with if they could converse with us in English rather than in a programming language.
16. The critical (analytical) thinking needed to develop computer programs helps me to organize my thoughts not only in math-related subjects but also in other school subjects.
17. Learning a programming language takes quite a while and is a waste of time.
18. Computers should be incorporated in all high school subjects not only those that are mathematically orientated.
19. I want to take more computer courses either in high school or in college.
20. We can get along in society with hand-held calculators and slide rules, and we do not need the assistance of high-speed computers.
21. I would advise any of my friends to take computer courses.
22. I would rather solve tedious and complicated math problems by hand rather than by computer.
23. My high school should dispose of all computer equipment.
24. I appreciate computers in society because I understand the value of the computer to people.

Table 2

Results of Pilot Survey by Item Analysis

Item No.	Corr. to Table 1 No.	Wt.	Alpha-X	Var	Corel	Val
1	24	P	.861	.588	.486	-.225
2	5	P	.865	1.012	.337	.001
3	6	N	.852	1.592	.697	-.104
4	2	N	.855	1.458	.638	-.215
5	7	P	.857	.790	.603	-.243
6	1	P	.859	1.123	.523	.027
7	22	N	.872	1.386	.162	-.009
8	3	N	.869	.516	.104	.336
9	19	P	.846	1.419	.848	-.211
10	13	P	.857	1.596	.593	.016
11	4	N	.872	1.166	.122	.161
12	21	P	.863	1.079	.406	.065
13	12	N	.849	1.485	.789	-.130
14	20	N	.866	1.419	.353	-.156
15	8	P	.864	1.311	.408	-.022
16	10	P	.869	.971	.210	.094
17	11	P	.855	.980	.667	-.236
18	23	N	.857	.867	.607	-.047
19	9	P	.860	1.201	.518	-.322
20	14	N	.853	.880	.743	-.211
21	15	N	.870	1.241	.206	-.095
22	17	N	.857	.829	.594	-.169
23	16	P	.854	1.189	.677	-.072
24	18	P	.860	1.459	.515	-.038

Table 3

Frequencies Tallied by Choice Per Item in Pilot Survey

Item No.	Corr. to Table 1 No.	Non-Read/ Omit	A	B	C	D	E
1	24	0	24	33	16	1	0
2	5	0	1	11	16	31	15
3	6	0	12	17	16	21	8
4	2	0	7	19	16	22	10
5	7	3	11	24	29	6	1
6	1	2	4	13	27	18	10
7	22	1	3	11	9	25	25
8	3	0	32	36	5	0	1
9	19	0	14	18	23	13	6
10	13	0	8	3	14	24	25
11	4	1	4	10	20	27	12
12	21	0	10	28	21	12	3
13	12	0	5	6	12	21	30
14	20	1	6	2	10	23	32
15	8	1	9	13	27	16	8
16	10	1	1	13	25	23	11
17	11	1	14	20	28	10	1
18	23	1	3	0	4	20	46
19	9	2	12	21	25	9	5
20	14	1	3	1	15	35	19
21	15	1	23	19	18	12	1
22	17	0	2	4	15	38	15
23	16	0	7	25	25	10	7
24	18	1	11	22	19	13	8

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Table 4

Results of Principal Survey by Item Analysis

Item No.	Weight	Alpha-X	Var	Corel	Val
1	P	.833	.934	.555	.271
2	N	.836	1.263	.497	-.001
3	N	.841	.951	.336	.043
4	N	.839	1.247	.428	.017
5	P	.839	1.493	.433	.058
6	N	.833	1.039	.578	.062
7	P	.838	.815	.426	.007
8	P	.843	1.507	.349	-.094
9	P	.838	1.151	.440	.079
10	P	.844	.878	.242	-.016
11	P	.840	.949	.362	.059
12	N	.827	1.118	.716	.202
13	P	.829	1.453	.649	.178
14	N	.832	.745	.623	.187
15	N	.847	1.173	.219	.077
16	P	.833	.768	.589	.058
17	N	.832	.649	.634	.199
18	P	.836	1.111	.501	-.107
19	P	.825	1.298	.747	.260
20	N	.843	.933	.279	.114
21	P	.831	.975	.616	.113
22	N	.842	1.030	.329	-.030
23	N	.836	.810	.499	.099
24	P	.838	.666	.407	.011

Table 5

Frequencies Tallied by Choice Per Item in Principal Survey

Item No.	Non-Read/ Omit	A	B	C	D	E
1	5	32	90	67	24	7
2	2	17	51	51	81	23
3	3	62	98	40	17	5
4	1	9	35	38	90	52
5	2	17	35	52	65	54
6	5	15	28	70	87	20
7	26	42	60	83	10	4
8	0	25	55	49	66	30
9	12	36	61	63	45	8
10	6	6	20	68	92	33
11	5	45	78	70	23	4
12	1	10	8	27	73	106
13	2	29	21	65	75	33
14	13	2	10	34	103	63
15	2	57	85	46	27	8
16	5	11	72	93	37	7
17	1	3	7	31	124	59
18	2	19	80	66	43	15
19	1	54	79	52	26	13
20	1	6	7	25	68	118
21	3	32	104	54	23	9
22	0	5	14	32	72	102
23	1	7	3	11	55	148
24	4	59	114	40	5	3

Table 6

Total Test Statistics

Pilot Survey	
Mean Score	5.77
Standard Deviation	12.71
Variance	161.42
Mean Score Per Item Reached	.24
Alpha Reliability Estimate	.865
Lambda 2 Reliability Estimate[a]	.879
Alpha for a One-Item Test	.211
Standard Error of Measurement	4.412
Variance Error of Measurement (Based on Lambda 2 Reliability Estimate	19.465
Correlation Between Total Test Score and External Criterion	-.1570
Principal Survey	
Mean Score	9.70
Standard Deviation	11.60
Variance	134.53
Mean Score Per Item Reached	.32
Alpha Reliability Estimate	.843
Lambda 2 Reliability Estimate[a]	.858
Alpha for a One-Item Test	.151
Standard Error of Measurement	4.602
Variance Error of Measurement (Based on Lambda 2 Reliability Estimate)	21.177
Correlation Between the Total Test Score and External Criterion	.1442

[a] Lambda 2 reliability estimate, attributed to Guttman, is known to be at least as good as coefficient alpha. In fact, it is usually better.

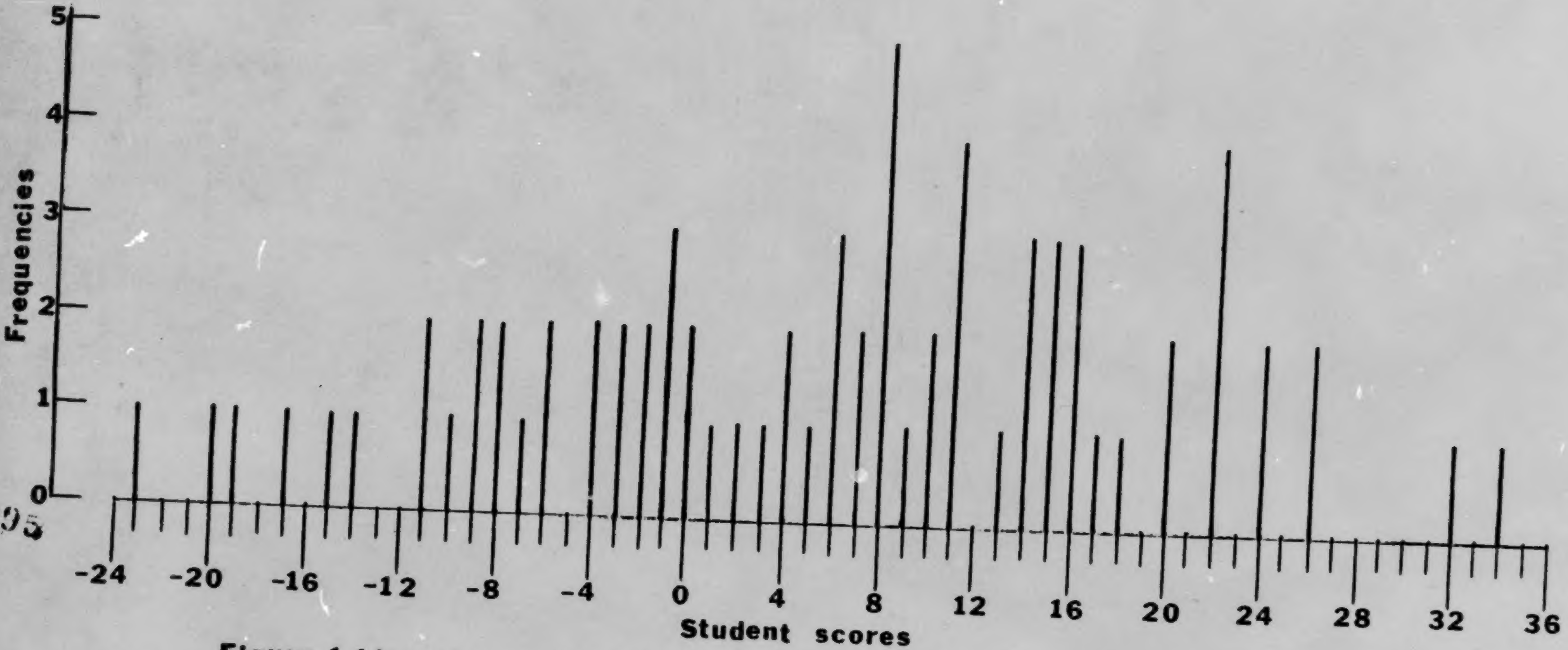

Figure 1. Line-segment graph: Distribution of scores from the pilot survey

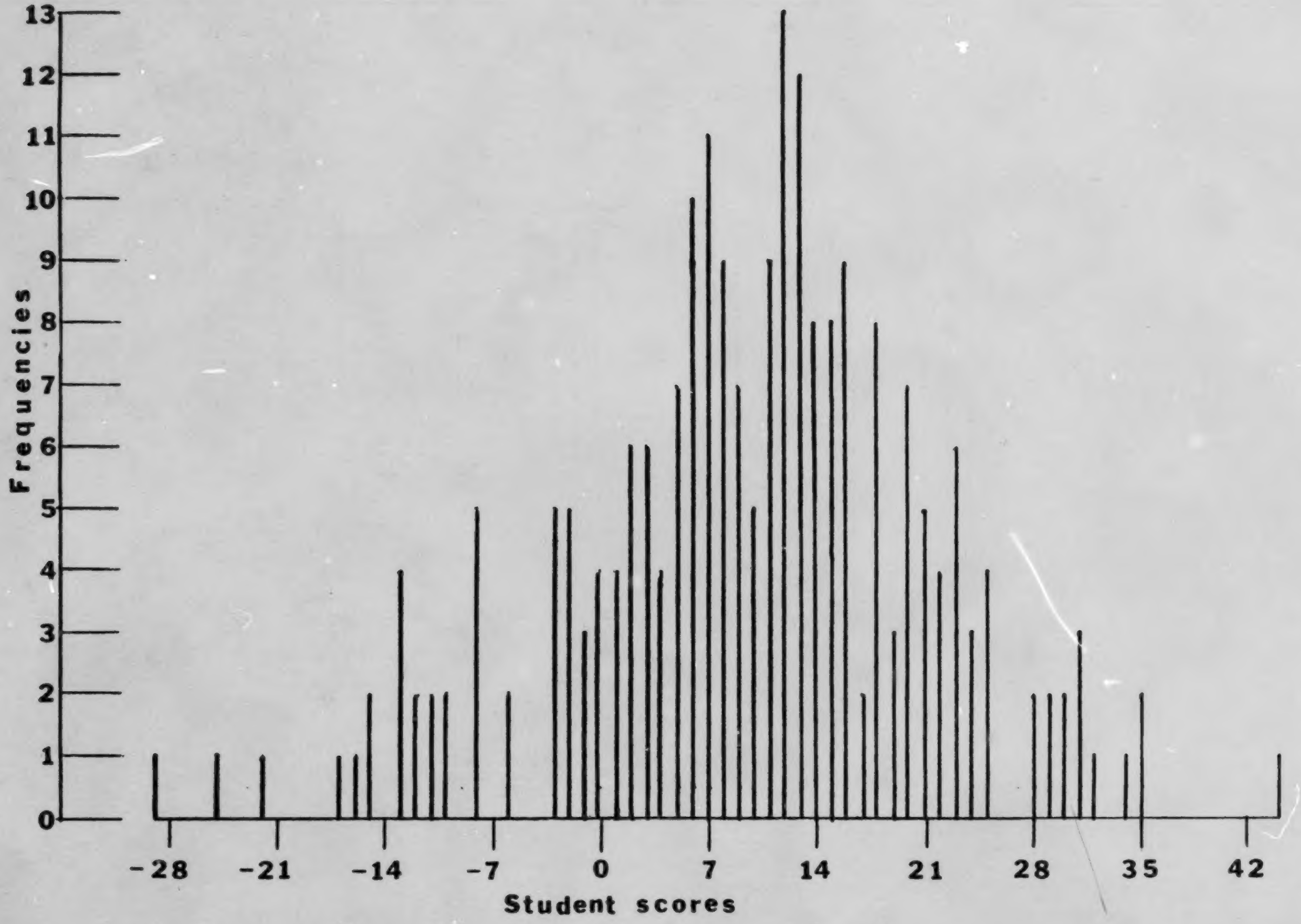

Figure 2. Line-segment graph: Distribution of scores from the principal survey

Decision-Making In A Large Public School System

Catherine E. Morgan

Montgomery County (Md.) Public Schools

The Montgomery County (Md.) Public Schools began, in the spring of 1976, to design and develop an integrated set of instructional systems. The four systems are intended (1) to monitor individual student progress in mathematics, reading/language arts, science and social studies from kindergarten through eighth grade, and (2) to provide information for decision making at all levels from the classroom to the Board of Education.

Instructional Systems

The mathematics system was the first to be completed and was piloted in 15 schools during the 1976-77 school year. The current system is in 77 schools with over 40,000 students. The second system, that of reading/language arts, is being piloted in 19 schools during this school year. The five-year plan, dated January, 1976, calls for all systems to be in all elementary, middle and junior high schools by June, 1981. Each system has a curriculum consisting of sets of sequenced and leveled objectives; an instructional component including guides with sample teaching activities, assessment items, and coded to all approved related print and non-print materials; an assessment component of criterion-referenced items on the objectives; a variety of reports and a management component which provides for in-servicing teachers, aides and principals, continuing support to school staffs and for revising, modifying and updating the system components. The systems assure consistent curriculum and assessment in all schools. Creative uses of instructional materials, activities, strategies and organizational patterns are encouraged and none mandated.

Data Collected

The data collected varies with the system, but for all systems, the regular MCPS computerized pupil information is available. These common elements provide easy access to reports, for example, by grade, school, sex, race or handicapping conditions. Data is kept on the current status of each student. In the mathematics system, the achievement on the beginning objective in each category, on the current objective and the last date tested are maintained. Additional information is kept on the achievement of word problems and basic facts. In the reading/language arts system, information is maintained on objectives by the type of discourse (narrative, expository and procedural), the aggregated scores on different types of inference and on such global outcomes as retelling, paraphrasing, summarizing and outlining. The reading/language arts system's major objectives are for students to comprehend and produce coherent discourse and not on a set of minute discreet objectives. Students in MCPS generally do well in decoding or word calling and, therefore, the decoding part of the system will only be used with students having that difficulty. In any case, no instruction is recommended which is not embedded in meaning.

Decision-makers

Within any school system, management decisions are made by staff at all levels. These include:

At the school level --

- classroom teachers
- adjunct teachers
- media specialists
- resource teachers
- principals

At the area level --

- subject teacher specialists
- supervisors of instruction
- area directors for instruction
- associate superintendents

At the central office level --

- curriculum developers
- department directors
- associate superintendent for program development
- superintendent
- Board of Education

At the school level, the system should provide assistance in answering questions such as:

What does each student already know?

What should he/she be learning next?

How do the students achieve in relationship to each other?

How shall they be grouped for instruction?

How shall I plan for this class over the entire school year? Where shall I begin?

Are there students not making any progress or less than satisfactory progress?

How do I report and conference with parents on individual student progress?

How can an Individual Educational Plan be prepared for those students that the law prescribes?

What materials are suggested for teaching each topic?

How will the students be tested?

What materials shall we buy?

How shall we use the human resources available within the school?

How do the media center and its specialist contribute?

Is a comprehensive instructional program being taught or are certain topics ignored or slighted?

Which instructional areas within the school are progressing well? Which need help?

Does my staff need in-servicing in the subject area or with grouping and individualizing?

Area personnel are interested in knowing:

How is each school achieving in each curricular area?

Where should the supervisors and specialists provide additional help?

Do certain populations within the area need additional resources?

Shall we allot more monies for instructional materials?

Shall we reallocate aides and teachers based on need?

At the central office, all of the above questions are pertinent except those relating to direct instruction. Curriculum developers want to know:

How does the data support the sequencing and leveling of the objectives?

In which categories and objectives do large numbers of children require retesting?

What materials and strategies appear to work best?

Do we need to identify or develop our own instructional materials where difficulties appear?

The superintendent and the Board of Education will also want to know:

How do the district results on standardized tests compare with those on MCPS curriculum?

In which areas of the curriculum are less than satisfactory results being observed?

How can we best allocate the available resources to strengthen the instructional program?

Are the students at both ends of the continuum being served effectively?

Other central office staff may pose questions such as:

What in-service courses need to be offered by school, area and district?

Reports

Information on individual student achievement and class profiles are available to school staffs on a regular basis. These reports (Attachment Nos. 1, 2 and 3 attached) illustrate where students are presently achieving and how they may be grouped for instruction in different topics. Aggregated information is also provided to schools (Attachment No. 4) which show which categories were taught and tested, which students were not tested and at what level and how well students are doing in problem solving. Area and county reports provide information on percentages of students achieving above, on and below expectancy by grade, sex and race.

Possible Interpretations and Uses of Information

School systems rarely have current information on which to base decisions. Standardized tests rarely are given more often than every two years. The results are not intended to provide instructional information and rarely does a school system's curriculum match the items on a standardized test. The Iowa Test of Basic Skills is used in Montgomery County. Approximately 35% of the mathematics curriculum is reflected in the test and 10% of the ITBS test items are not taught in MCPS. Much of what a school system wants their students to accomplish cannot be tested in a multiple-choice format or even in other paper and pencil forms.

What if someone asked you what percentages of the kindergarten students can demonstrate an understanding of the numbers 1-10 through the use of concrete objects? In our system, we can tell you.

Some short examples of how information is used by several groups of people follow. Teachers are provided with individual student profiles and class profiles prior to school opening for their incoming classes. Using these, they can make plans for the entire school year, not lesson plans, but comprehensive plans on what related categories they will begin instruction, to what new ones they will progress and when they will recycle back to the original topics. In a general way, they can map out a school year. Moreover, as they will continue to receive updated information, they can revise or modify their plans at any time. The important information for grouping is available from the class profiles. Whenever they test one or more students in a category, they will receive an updated class profile.

Curriculum coordinators get reports which aggregate the data. They can ascertain in which areas students are experiencing the most difficulty. By conferring with teachers and specialists, they may find that certain objectives are placed at incorrect grade levels. For example, in MCPS, we find similar results to those of the National Assessment examinations in the area of common fractions. Students are not able to compute using common fractions in the upper elementary grades where these topics are normally presented. How much non-productive teacher and student time is spent trying to teach a topic which might be better delayed a year or two?

Inventories of manipulative materials have been made in all schools and where shortages were observed, these materials have been made available. School staffs have become aware of their need to group students for instruction. This reaction has been noticeable, particularly at the junior high level, where total class instruction had been the rule but where the information from the reports showed that mode did not meet the needs of the students. All students who are not severely mentally retarded are in the systems and records have shown that achievement has been significantly changed.

To date, most of the information has been used to improve instruction, provide for individual needs, monitor student progress, and modify and revise the curriculum. We expect dramatic new uses for the information in the areas of prioritization of needs and allocation of resources.

MONTGOMERY COUNTY PUBLIC SCHOOLS
ROCKVILLE, MARYLAND 20850

School: EASEWOOD ELEMENTARY SCHOOL

Teacher: MRS. LANCASTER

CLASS PROFILE BY CATEGORY

Grade 4 Group/Period 2

Date: SEPTEMBER 17, 1977

Category: MULTIPLICATION

*	BASIC PROFICIENCY
DEMO	DEMONSTRATION ITEM
P-P	PAPER AND PENCIL ONLY
M	OBJECTIVE MASTERED
@	OBJECTIVE ATTEMPTED

Attachment 1

SAMPLE DATA

	KEY OBJECTIVE NUMBER AND LEVEL METHOD OF ASSESSMENT.		01-F DEMO	04-H	05-H	06-I	07-K *													
1.	ALLEN	KATIE																		
2.	BROWN	BILL																		
3.	JOHNS	MARCIA																		
4.	YOUNG	SAM																		
5.	MATHIS	ANN	M	@																
6.	NELSON	NICK	M	@																
7.	RANKIN	PAM	M	@																
8.	STEVENS	TERRY	M	@																
9.	WALSH	RICK	M	@																
10.	ASHE	JENNY	--------	--M																
11.	BASCH	DAVE	--------	--M																
12.	CARR	LYNN	--------	--M																
13.	GRIFFIN	DEENA	--------	--M																
14.	MARCUS	JOHN	--------	--M																
15.	NIBLEY	LARA	--------	--M																
16.	DORN	SUE	--------	--M																
17.	GREENE	PAT	--------	--M																
18.	LANG	MARK	--------	--M																
19.	SWISHER	ERIC	--------	--M																
20.	THORNE	ALICE	--------	--M																
21.	DAY	ANDREA	--------	--M																
22.	JONES	EDWARD	--------	--M																
23.	LEWIS	MICHAEL	--------	--------	---M															
24.	PIERCE	SANDRA	--------	--------	---M															
25.	STEVENSON	PETER	--------	--------	---M															
26.	HAYES	SUSAN	--------	--------	---M															
27.	THOMPSON	ERIC	--------	--------	---M															
28.	REED	KERI	--------	--------	---M															
29.	GOLD	NATHAN	--------	--------	--------	--M														
30.	CLARK	JOANNE	--------	--------	--------	--M														
31.																				
32.																				
33.																				
34.																				
35.																				
36.																				
37.																				
38.																				
39.																				
40.																				
41.																				
42.																				
43.																				
44.																				
45.																				

MCPS FORM 345-30, Revised July, 1977

MONTGOMERY COUNTY PUBLIC SCHOOLS
ROCKVILLE, MARYLAND 20850

CLASS PROFILE BY CATEGORY

★	BASIC PROFICIENCY
DEMO.	DEMONSTRATION ITEM
P-P	PAPER AND PENCIL ONLY
M	OBJECTIVE MASTERED
@	OBJECTIVE ATTEMPTED

School: EASEWOOD ELEMENTARY

Teacher: MRS. LANCASTER

Grade: 4 Group/Period: 2

Date: APRIL 20, 1977

Category: BASIC FACTS

Attachment 1

	OPERATION KEY OBJECTIVE NUMBER AND LEVEL		ADD 01-E	SUB 02-E	ADD 03-G	SUB 04-G	MULT 05-H	DIV 06-H	MULT 07-H	DIV 08-J
	MASTERY/TOTAL FACTS		63/66	63/66	34/36	34/36	48/50	43/45	38/40	34/36
1.	ALLEN	KATIE	M	M	M	M	45	40		
2.	ASHE	JENNY	M	M	21	32				
3.	BASCH	DAVE	M	M	M	M	M	M	M	32
4.	BROWN	BILL	M	M	M	M	46	40		
5.	CARR	LYNN	M	M	M	M	M	41	M	
6.	CLARK	JOANNE	M	M	M	M	M	M	M	30
7.	DAY	ANDREA	M	60	M	33	43			
8.	DORN	SUE	M	M	M	M	M	M	35	
9.	GOLD	NATHAN	M	M	M	M	M	M	M	M
10.	GREENE	PAT	M	M	30	M	M	41		
11.	GRIFFIN	DEENA	M	M	M	M	M	M	M	M
12.	HAYES	SUSAN	M	M	M	M	47	41		
13.	JOHNS	MARCIA	M	M	M	M	M	M	36	
14.	JONES	EDWARD	M	M	M	M	M	40	[illegible]	
15.	LANG	MARK	M	55	M	31	42	[illegible]	[illegible]	
16.	LEWIS	MICHAEL	M	M	M	M	[illegible]	[illegible]	[illegible]	
17.	MARCUS	JOHN	M	M	M	[illegible]	[illegible]	[illegible]	34	
18.	MATHIS	ANN	M	M	[illegible]	[illegible]	[illegible]	[illegible]		
19.	NELSON	NICK	M	[illegible]	[illegible]	[illegible]	[illegible]			
20.	NIBLEY	LARA	M	M	[illegible]	[illegible]	M	40	36	
21.	PIERCE	SANDRA	M	M	[illegible]	M	M	M	M	M
22.	RANKIN	PAM	M	M	29	27				
23.	REED	KERI	M	M	M	M	M	M	M	M
24.	STEVENS	TERRY	M	M	M	M	40			
25.	STEVENSON	PETER	M	62	M	32				
26.	SWISHER	ERIC	M	M	M	M	M	M	36	
27.	THOMPSON	ERIC	M	M	M	M	47	39		
28.	THORNE	ALICE	M	58	M	M	M	42	36	
29.	WALSH	RICK	M	M	32	30				
30.	YOUNG	SAM	M	M	M	M	M	M	M	M
31.										
32.										
33.										
34.										
35.										
36.										
37.										
38.										
39.										
40.										
41.										
42.										
43.										
44.										
45.										

SAMPLE DATA

165

308

307

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MONTGOMERY COUNTY PUBLIC SCHOOLS
ROCKVILLE, MARYLAND 20850

STUDENT PROFILE

Attachment 2

School: EASEWOOD ELEMENTARY
Teacher: MRS. LANCASTER
Student: JOANNE CLARK

Grade 4 Group/Period 2
Date: APRIL 28, 1977

FOR EACH CATEGORY:
1. ■ - NO OBJECTIVES AT THIS LEVEL
2. □ - NO KEY OBJECTIVES AT THIS LEVEL
3. FIRST NUMERAL - BEGINNING OBJECTIVE CURRENT YEAR
4. SECOND NUMERAL - HIGHEST KEY OBJECTIVE MASTERED

Estimated Working Level: 2

592

Category (Highest Key Objective) / LEVEL	A (0)	B (8)	C (10)	D (10)	E (16)	F (12)	G (8)	H (15)	I (14)	J (17)	K (14)	L (12)	M (13)	N (7)	O (3)	P (14)	Q (11)	R (6)	LAST DATE TESTED
Numeration (30)					25---				--28										1/18
Place Value (12)									12										9/17
Addition (11)										11									9/17
Subtraction (11)							09---		---------	--11									3/11
Multiplication (07)								04---	--06										4/18
Division (10)						02--		--------	--------	--07									4/18
Money (08)								04											9/28
Time & Temperature (12)						06--		-------		--09									4/01
Length (12)						04--	--------		--07										4/22
Capacity (05)								03											4/20
Weight & Mass (06)					02--			--03											3/16
Area & Volume (12)																			
Geometric Figures (46)							14												9/28
Statistical Graphs & Tables (26)							09---	--13											3/07
Coordinate Graphs (10)									03										4/25
Common Fractions (32)							06---	--------	--14										3/27
Decimal Fractions (18)																			
Ratio and Percent (12)																			
Number Sentences (07)						05--				--06									3/15
Factors & Multiples (09)																			
Estimation & Rounding (09)																			
Exponents & Scientific Notation (11)																			
Positive & Negative Numbers (12)																			

SAMPLE DATA

BASIC FACTS

	ADD	SUB	MULT	DIV
EASIER	M	M	M	
HARDER	M	M	M	

PROBLEM SOLVING

LEVEL	H
PERCENT CORRECT	80
DATE TESTED	3/21

309

MCPS FORM 345-29, Revised July, 1977

Attachment 3

MCPS:ISR/LA
7/17/78

LEVEL 2

STUDENT

PERFORMANCE OBJECTIVES

P.1

-----CHARACTER------				DIALOGUE		-------EVENTS-------				--VOCABULARY--			-------SYNTAX-------				TOTAL
SN	SN	SN	SN	SN	FT	SN	SN	SN	FT	SN	SN	FT	SN	SN	SN	SN	
5	11	12	20	7	5	1	3	25	7	29	39	+ 11	17	+ 18	+ 19	+ 22	
N=5	N=4	N=4	N=5	N=5	N=5	N=4	N=4	N=5	N=5	N=4	N=4	N=2	N=2	N=2	N=2	N=2	

P.2

--------ASPECTS OF DISCOURSE---------					INFERENCE CATEGORIES			-------FORM OF DISCOURSE---------					TOTAL
CHARTR	DIALOG	EVENTS	VOCABU	SYNTAX	1	2	3	SHNAR	NOVEL	FOLKT	FABLE	AUTOB	
N=17	N=9	N=18	N=10	N=8	N=20	N=28	N=10	N=52		N=12			

MCPS:ISR/LA
7/17/78

LEVEL 3

STUDENT

PERFORMANCE OBJECTIVES

594

	CHARACTER		DIAL	---EVENTS---			-VOCABULARY-			TOTAL
P.1	SN	SN	SN	SN	SN	SN	SN	FT	SN	
	1	11	9	16	17	24	28 +	7	31	
	N=8	N=8	N=8	N=8	N=8	N=8	N=4	N=4	N=8	

	---------ASPECTS OF DISCOURSE---------					INFERENCE CATEGORIES			-------FORM OF DISCOURSE--------					TOTAL
P.2	CHARTR	DIALOG	EVENTS	VOCABU	SYNTAX	1	2	3	SHNAR	NOVEL	FOLKT	FABLE	AUTOB	
	N=16	N=8	N=24	N=16		N=10	N=40	N=14	N=60		N=4			

MCPS:ISR/LA
7/17/78

LEVEL 4

STUDENT

PERFORMANCE OBJECTIVES

P.1

CHARACTER						DIALOGUE			EVENTS				VOCABULARY				TOTAL
SN	NO	SN	FA	SN	FA	SN	NO	NO	SN	NO	SN	NO	SN	NO	SN	NO	
1 +	1	7 +	3	8	4	4 +	10	11	13 +	17	14 +	18	22 +	27	24 +	29	
N=3	N=3	N=3	N=3	N=6	N=6	N=3	N=3	N=6	N=3	N=3	N=3	N=3	N=4	N=4	N=4	N=4	

P.2

ASPECTS OF DISCOURSE					INFERENCE CATEGORIES			FORM OF DISCOURSE					TOTAL
CHARTR	DIALOG	EVENTS	VOCABU	SYNTAX	1	2	3	SHNAR	NOVEL	FOLKT	FABLE	AUTOB	
N-24	N-12	N-12	N-16		N-10	N-39	N=15	N=29	N=26		N=9		

MCPS:ISR/LA
7/17/78

LEVEL 5

STUDENT	PERFORMANCE OBJECTIVES										
	P.1	-CHARACTER--			--DIALOGUE--			EVENT	VOCABULARY		TOTAL
		NO	AB	NO	NO	NO	NO	NO	NO	NO	
		11 +	15	16	11	12	13	19	33	34	
		N=4	N=4	N=8	N=8	N=8	N=8	N=8	N=8	N=8	

P.2	---------ASPECTS OF DISCOURSE---------					INFERENCE CATEGORIES			------FORM OF DISCOURSE---------					TOTAL
	CHARTR N=16	DIALOG N=14	EVENTS N=8	VOCABU N=16	SYNTAX	1 N=8	2 N=40	3 N=16	SHNAR	NOVEL N=60	FOLKT	FABLE	AUTOB N=4	

MCPS:ISR/LA
7/17/78

LEVEL 6

STUDENT

PERFORMANCE OBJECTIVES

P.1	CHARACTER		--DIALOGUE--			EVENT	VOCABULARY		TOTAL
	NO	NO	NO	NO	NO	NO	NO	NO	
	11	13	8	9	10	22	34	35	
	N=8	N=8	N=8	N=8	N=8	N=8	N=8	N=8	

P.2	---------ASPECTS OF DISCOURSE---------					INFERENCE CATEGORIES			-------FORM OF DISCOURSE---------					TOTAL
	CHARTR N=16	DIALOG N=24	EVENTS N=8	VOCABU N=16	SYNTAX	1 N=7	2 N=34	3 N-23	SHNAR	NOVEL N=64	FOLKT	FABLE	AUTOB	

MONTGOMERY COUNTY PUBLIC SCHOOLS
ROCKVILLE, MARYLAND 20850

MONTHLY ASSESSMENT REPORT

Attachment 4

School: EASEWOOD ELEMENTARY

Grade: 4 Group/Period: 2

Date: APRIL

Teacher: MRS. LANCASTER

CATEGORIES (NUMBER OF STUDENTS) ASSESSED	STUDENTS NOT ASSESSED IN ANY CATEGORY	STUDENTS READY FOR ASSESSMENT IN PROBLEM SOLVING		STUDENTS TESTED IN PROBLEM SOLVING		
		NAME	LEVEL	NAME	LEVEL	PERCENT CORRECT
MULTIPLICATION (5)	BILL BROWN	ANN MATHIS	F	NATHAN GOLD	J	80
DIVISION (21)	LYNN CARR	MARK LANG	H	JOANNE CLARK	H	90
LENGTH (14)	ERIC THOMPSON	ERIC SWISHER	H	MICHAEL LEWIS	H	80
WEIGHT AND MASS (7)		DEENA GRIFFIN	G	SANDRA PIERCE	H	90
GEOMETRIC FIGURES (10)		PAM RANKIN	G	JENNY ASHE	G	80
STATISTICAL GRAPHS AND TABLES (13)		RICK WALSH	F			
COORDINATE GRAPHS (2)		ANDREA DAY	H			
		TERRY STEVENS	G			
		KATIE ALLEN	E			
		KERI REED	I			

SAMPLE DATA

MCPS FORM 335-31, Revised July 1977

CONTEXT: A Challenge for the Language Arts CAI Developer

John G. Allee, Jr.
The George Washington University

Robert L. Williams
St. John's University, New York

Language Arts CAI--grammar and usage, for example--provides the CAI developer opportunities to use the computer terminal dynamically in ways far superior to the traditional textbook, if language and the terminal are assessed and employed carefully.

Essentially, language is speech--sets of sound symbols--live, immediate oral communication among people, and these conventionalized sounds and utterances are practiced and polished almost from birth. They permeate the individual's life even before school, as they are received and interpreted by ear, produced and sent by mouth to an expanding, visible audience, personal, and interactive. Only secondarily is language writing--written symbols representing a significant portion of the sound symbols--this another kind of stylized communication that is practiced normally in schools only after age six. Although writing limitedly affects the individual's life at first, its impact increases progressively through the school years, as it is received by sight and reinforced by ear and sometimes reproduced to be sent to a limited audience that is often impersonal, static, frequently almost non-interactive so the good faith corrections and recorrections available in oral language virtually disappear. Thus, human language becomes two languages--both mutually supportive and competitive.

Reading--the receiving and interpreting of the partial speech symbols by eye--is the school's primary concern, so that failure with reading impedes or denies almost all other intellectual pursuits in our culture. Reading even significantly affects the acquisition of quantitative processes--arithmetic and mathematics--a school's second primary concern. But in order to go from speech language to written language so that there can be a mastery of language sufficient for all learning, educators have empirically found that a whole discipline of language--"grammar"--becomes a third primary concern among the skill disciplines.

From a practical point of view grammar, or the study of language, is as necessary as it is difficult to achieve. Some of the difficulty arises, of course, because of the relative abstractness of grammar and its accompanying "seeming uselessness." Thus students (and teachers) often do not see how to apply the theory (of grammar) to the use and performance in language and the quantitative skills. In part the fault lies in all-too-partial mastery that comes not only from some lack of understanding but also from lack of practice. But how to get the necessary practice without repetition or drill? Of course, it's been said practice makes permanent not perfect, so that the drill must be totally accurate and interesting enough to do!

In most language instruction--grammar and usage--the teacher strives to present language practice contextually. But even in the best of circumstances, most teaching situations are artificial--divorced, as it were, from actual lifework and play--, and true context cannot be reached in either written or spoken language systems. With language, in one sense, it seems easier to address written usage since writing is stylized and static whereas speech is dynamic, personal, and considerably more dependent upon setting and expected interplay. Yet both "languages" are one language. As said before, for both the student and the teacher the two are competitive: the distinctions between them are neither easily discerned nor easily isolated for attention. However, a teacher who constantly attempts to simulate the best contextual situations for language instruction is more apt to be treating "real language" than one who does not. The teacher, by the ability to act, interact, and re-act face to face with students, can stage or simulate contexts that impart keen language insights helpful to students. Such a teacher carries language instruction far beyond the confines of the best textbook. Admittedly this personal interaction is largely denied the developer of CAI.

Even though facing the same contextual needs as the classroom teacher, the developer must try to stage or simulate language contexts somewhat differently. He must transfer what would otherwise be his personal role in the classroom to the terminal.

Let's consider a problem of context that is faced by both the teacher and the CAI developer. The English articles--*a* and *the*--provide a case in point:

A1. Do you have a dog, Tom?
A2. There is a cat here, Tom.
T1. The dog is barking, Tom.
T2. There is the cat, Tom.

The two A sentences would appropriately open or initiate responses and conversations, that is, establish context. *Dog* and *cat* are identified or marked by the article *a*. On the other hand, the T sentences would normally not open or initiate communication unless previous contexts had been established by prior communication (i.e., conversation and/or physical relationships between individuals). In these sentences *dog* and *cat*, identified or marked by *the*, could be considered "valid" only if prior contexts to accept them had been established.

Now let's look at the following set of exercises typically from a traditional textbook:

Set A

Use *is* or *are* to complete these sentences.

1. The boy ___ speaking to Tom.
2. The girl ___ happy.
3. There ___ a boy near Tom.
4. A girl ___ talking to Tom.

In sentences 1 and 2 *boy* and *girl* are marked by *the*; no contexts have been established for these nouns. In one sense for the student, it's as if he or she has been "dropped" into the middle of a conversation. Sentences 3 and 4 introduce *boy* and *girl* by marking them with *a* so that no prior contexts or antecedents are necessary. Let's see if we can get the same "drill" in but at the same time bring the sentences closer to real life language, that is, in context.

Set B

1 (3). There ___ a boy near Tom.
2 (4). A girl ___ talking to Tom.
3 (1). The boy ___ speaking to Tom.
4 (2). The girl ___ happy.

Now, boy and girl of sentences 3 (1) and 4 (2) could be assumed to have been introduced in sentences 1 (3) and 2 (4). They now have a context.

Rather obviously these sentences have now been logically arranged to demonstrate an aspect of the English article system. In the event a classroom teacher and students were using a textbook presenting Set A and in the event the students were to raise questions about language logic, the teacher, if available of course, and if there were time for all sets of questions, would respond to these questions. Were the students considering the same exercise in a CAI lesson they most likely would not have the teacher's assistance or interaction. Thus, how can language arts CAI, where instances of context are crucial, overcome the difficulties?

The context example cited above is not as simple as it might appear at first glance.

Set C

A boy is talking to John.
The boy is also talking to Mary.

These appear acceptable. But let's pluralize boy.

Set D

--- boys are talking to John.
The boys are also talking to Mary.

The dashes might be filled in with some, several, three, ... Because the article "flows" or "branches" into other grammatical subsystems, or vice versa, in effect, the articles are also members of a larger subsystem, the determiners. The particular issue at hand (articles) and other issues (determiners) that may suddenly come into consideration demand careful analysis by the CAI developer. Language subsystems are not easily isolated for study or practice, whether for textbook, CAI, or teacher presentation. Thus, for the CAI developer, any subject matter to be presented must be studied and considered most carefully and logically. Were the developer, without cogent study, to seize upon items from traditional textbooks--items the teacher can explain (if time permits) and handle through classroom interaction, the resulting CAI exercises would unfortunately reproduce the lack of logical clarity and naturalness of the textbooks. Where traditional textbook material is transferred to individualized CAI, the limitations then become magnified.

Although not so fully as a good classroom teacher, the terminal (or CAI program) does react and interact with the student. The terminal's interaction is immediate--this is perhaps its chief asset to the student. However, the quality of interaction is limited. On the other hand, not all teachers are equally adept at language instruction and interaction or have the time to answer questions: some are excellent, others are not. One might assume also that CAI may vary in quality, but can CAI dare to be less than excellent?

In short, the terminal, first, should not simply transfer magnified limitations from textbooks. Second, the interactive powers of the terminal should be assessed carefully by the developer and used in CAI development. Moreover, since the student can be prompted by the terminal, he should be employed, wherever possible, as an active participant in developing language CAI. The student participating with the terminal, for instance, can indirectly help solve some of the problems that language instruction imposes: context--exampled by one problem noted earlier--can be made almost real by the student because the student can be asked, for example, to input characters--names of his classmates--which the terminal then can use in its presentations. In effect, the student can help develop context and can be considered an instructional assistant by the CAI developer.

Below is the first stage of a lesson that asks the student to give the names of other classmates who are then to become characters within the lesson and its exercises:

```
LET'S ACT LIKE I'M A NEW CLASSMATE OF YOURS, JOHN.
TELL ME THE FIRST NAMES OF SOME OF OUR OTHER CLASSMATES,
THREE GIRLS AND THREE BOYS!

             READY  ?

     GIRL NUMBER 1 IS    ? SUE
        IS HER NAME--SUE--SPELLED CORRECTLY (YES, NO)    ? YES

     GIRL NUMBER 2 IS    ? ANN
        IS HER NAME--ANN--SPELLED CORRECTLY (YES, NO)    ? YES

     GIRL NUMBER 3 IS    ? JANE
        IS HER NAME--JANE--SPELLED CORRECTLY (YES, NO)    ? YES

     BOY NUMBER 1 IS    ? TOM
        IS HIS NAME--TOM--SPELLED CORRECTLY (YES, NO)    ? YES

     BOY NUMBER 2 IS    ? JACK
        IS HIS NAME--JACK--SPELLED CORRECTLY (YES, NO)    ? YES

     BOY NUMBER 3 IS    ? JO
        IS HIS NAME--JO--SPELLED CORRECTLY (YES, NO)    ? NO
     AGAIN, BOY NUMBER 3 IS    ? JOE
        IS HIS NAME--JOE--SPELLED CORRECTLY (YES, NO)    ? YES
```

In later lessons this first stage is shortened somewhat, but it seeks the same student participation:

```
FRED, TELL ME THE NAMES OF SOME OF OUR CLASSMATES!

     GIRL NUMBER 1 IS  ? JANET
        IS--JANET--CORRECT (YES,NO)  ? YES
     GIRL NUMBER 2 IS  ? SUE
        IS--SUE--CORRECT (YES,NO)  ? YES
     GIRL NUMBER 3 IS  ? MAY
        IS--MAY--CORRECT (YES,NO)  ? YES
     BOY  NUMBER 1 IS  ? BOB
        IS--BOB--CORRECT (YES,NO)  ? YES
     BOY  NUMBER 2 IS  ? JACK
        IS--JACK--CORRECT (YES,NO)  ? YES
     BOY  NUMBER 3 IS  ? TIM
        IS--TIM--CORRECT (YES,NO)  ? YES
```

A sequence of lessons within English Usage Exercises (EUX), a CAI unit composed of stand-alone programs, teaches (1) coordinating conjunctions, (2) prepositions, (3) countable nouns, (4) articles, (5) pronoun objects of prepositions, and (6) pronoun possessives. Within the pedagogical scheme of EUX, these topics interlock because the keystone is a limited set of nouns that force the student to look at and understand the article. In the prior 150+ sessions or lessons of EUX only a most limited, tangential role has been given the article, primarily because of the "difficulties" posed by the article and determiners suggested earlier.

A portion of EUX271--Connectors I--follows:

```
RUBIN, LET'S STUDY SOME SENTENCES:

 1 . SUE <AND> JANE ARE WHISPERING.

   'AND' IS A CONNECTOR.
   'AND' CONNECTS 'SUE' AND 'JANE.'  'AND' POINTS TWO WAYS.

              READY  ?

   TWO CLASSMATES ARE WHISPERING: BOTH 'SUE' AND 'JANE.'
   BOTH 'SUE' AND 'JANE' ARE SUBJECTS OF 'ARE WHISPERING.'

              READY  ?

   'AND' ADDS 'SUE' AND 'JANE' TO COUNT 2.
   'ARE' COUNTS 2 AND AGREES.

              READY  ?

 2 . JANE <OR> ANN IS TALKING.

   'OR' IS A CONNECTOR.
   'OR' CONNECTS 'JANE' AND 'ANN.'  'OR' POINTS TWO WAYS.

              READY  ?

   ONE CLASSMATE IS TALKING: EITHER 'JANE' OR 'ANN.'
   EITHER 'JANE' OR 'ANN' MAY BE THE SUBJECT OF 'IS TALKING.'

              READY  ?

   'OR' CHOOSES ONE, EITHER 'JANE' OR 'ANN,' TO COUNT 1.
   'IS' COUNTS 1 AND AGREES.

              READY  ?

 3 . THE BOY <NEAR< JACK IS LAUGHING.

   'NEAR' IS A CONNECTOR.
   'NEAR' CONNECTS 'THE BOY' AND 'JACK.'  'NEAR' ONLY POINTS ONE WAY.

              READY  ?

   ONE CLASSMATE IS LAUGHING: JUST 'THE BOY'--NOT 'JACK.'
   ONLY 'THE BOY' IS THE SUBJECT OF 'IS LAUGHING.'

              READY  ?

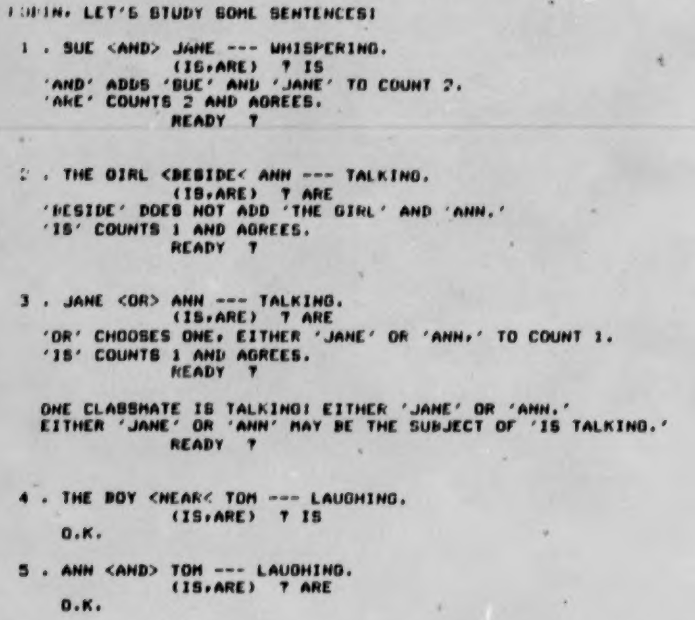
   'NEAR' DOES NOT ADD 'THE BOY' AND 'JACK.'
   'IS' COUNTS 1 AND AGREES.

              READY  ?

   'NEAR JACK' IDENTIFIES 'THE BOY.'
```

This session assumes that the student accepts the terminal as a classmate who is "speaking" or "writing" to him about other classmates within the student's (and the terminal's) own classroom context. Because the terminal has now been introduced to some other classmates, he can refer to others he's not been introduced to by citing them in/with prepositional phrases such as THE BOY NEAR..., for example.

Pedagogically, Connectors I does not treat the article--it simply employs the article. It compares and contrasts two coordinating conjunctions--*and* and *or*--and a few prepositions--like *behind* and *near*--in terms of a "counting" concept established and running through major portions of EUX, where the "counting" of verbs and subjects is used to treat, among other things, verb-subject concord, illustrated by the exercises of the second session of Connectors I:



```
JOHN, LET'S STUDY SOME SENTENCES!

 1 . SUE <AND> JANE --- WHISPERING.
               (IS,ARE)  ? IS
   'AND' ADDS 'SUE' AND 'JANE' TO COUNT 2.
   'ARE' COUNTS 2 AND AGREES.
               READY  ?


 2 . THE GIRL <BESIDE< ANN --- TALKING.
               (IS,ARE)  ? ARE
   'BESIDE' DOES NOT ADD 'THE GIRL' AND 'ANN.'
   'IS' COUNTS 1 AND AGREES.
               READY  ?


 3 . JANE <OR> ANN --- TALKING.
               (IS,ARE)  ? ARE
   'OR' CHOOSES ONE, EITHER 'JANE' OR 'ANN,' TO COUNT 1.
   'IS' COUNTS 1 AND AGREES.
               READY  ?

   ONE CLASSMATE IS TALKING! EITHER 'JANE' OR 'ANN.'
   EITHER 'JANE' OR 'ANN' MAY BE THE SUBJECT OF 'IS TALKING.'
               READY  ?


 4 . THE BOY <NEAR< TOM --- LAUGHING.
               (IS,ARE)  ? IS
    O.K.

 5 . ANN <AND> TOM --- LAUGHING.
               (IS,ARE)  ? ARE
    O.K.
```

As can be seen from the above, the student "counts" noun subjects, choosing the verb that agrees. The major language generality being taught is that nouns following prepositions do not alter sentence counts and/or that only and may alter "counts."

Similarly, O & S Markers I, EUX281, compares and contrasts verb and countable noun endings, the characters in the lesson being assigned by the student through the procedure shown earlier. Assuming that the student has accepted the terminal as a classmate within his classroom context, he interacts with the lesson material as follows:

```
GEORGE, LET'S PRACTICE!

A.  THE BOYS WITH MARY OFTEN TALK.
     1 . 'BOY' HAS WHAT ENDING  ? S
       YES.
     2 . 'TALK' HAS WHAT ENDING  ? O
       O. K.

B.  THE GIRL NEAR ALICE SOMETIMES LAUGHS.
     3 . 'GIRL' HAS WHAT ENDING  ? S
       NO.  O
     4 . 'LAUGH' HAS WHAT ENDING  ? O
       NO.  S

C.  THE BOYS BESIDE FRAN OCCASIONALLY WORKED, DIDN'T THEY?
     5 . 'BOY' HAS WHAT ENDING  ? S
       YES.
     6 . 'WORK' HAS WHAT ENDING  ? D
       O. K.
     7 . 'DO' HAS WHAT ENDING  ? D
       RIGHT.

D.  THE GIRLS BY TED FREQUENTLY SNICKER, DON'T THEY?
     8 . 'GIRL' HAS WHAT ENDING  ? S
       YES.
     9 . 'SNICKER' HAS WHAT ENDING  ? O
       O. K.
    10 . 'DO' HAS WHAT ENDING  ? O
       RIGHT.

E.  THE BOYS BEHIND LEWIS OFTEN WORK.
    11 . 'BOY' HAS WHAT ENDING  ? S
       YES.
    12 . 'WORK' HAS WHAT ENDING  ? O
       O. K.

F.  THE GIRL WITH JOHN SOMETIMES WORKED, DIDN'T SHE?
    13 . 'GIRL' HAS WHAT ENDING  ? O
       YES.
    14 . 'WORK' HAS WHAT ENDING  ? D
       O. K.
    15 . 'DO' HAS WHAT ENDING  ? D
       RIGHT.
```

The *O* and *S* marker concepts having been established in prior lessons, the student is here given noun subjects like *boy* with nouns--names of characters supplied by the student--interposed between the subjects and verbs in prepositional phrases (in these instances, nouns following prepositions do not add to the sentence "count"). But the point here is that to use nouns like *boy*, context can be simulated so that the grammatical attention given to nouns is met in "real" contextual sentences.

In a later series, after a request for classmate names, EUX311 treats noun and pronoun possessives:

```
MARY, LET'S PRACTICE!

        > THERE IS A BOY NEAR BOB AND JUNE.
    >> THE BOY IS A PARTNER OF BOB AND JUNE'S, ISN'T HE?

  1 . THE BOY IS A PARTNER OF -----, ISN'T HE?                 ? THEIR
        NO.  THEIRS

        > THERE ARE TWO BOYS BESIDE SAM AND ROSE.
    >> THE BOYS ARE SAM AND ROSE'S CLASSMATES, AREN'T THEY?

  2 . THE BOYS ARE ----- CLASSMATES, AREN'T THEY?              ? THEIR
        YES.

        > THERE ARE TWO GIRLS WITH JUNE.
    >> ARE THE GIRLS JUNE'S FRIENDS?

  3 . ARE THE GIRLS ----- FRIENDS?                             ? HER
        YES.

        > THERE IS A GIRL WITH ANN.
    >> THE GIRL IS ANN'S CHUM, ISN'T SHE?

  4 . THE GIRL IS ----- CHUM, ISN'T SHE?                       ? HER
        YES.

        > THERE IS A BOY NEAR SAM AND ROSE.
    >> ISN'T THE BOY SAM AND ROSE'S PARTNER?

  5 . ISN'T THE BOY ----- PARTNER?                             ? THEIR
        YES.

        > THERE ARE TWO GIRLS BESIDE JUNE AND BOB.
    >> ARE THE GIRLS PARTNERS OF JUNE AND BOB'S?

  6 . ARE THE GIRLS PARTNERS OF -----?                         ? THEIRS
        YES.

        > THERE IS A GIRL WITH ANN.
    >> IS THE GIRL ANN'S FRIEND?

  7 . IS THE GIRL ----- FRIEND?                                ? HER
        YES.

        > THERE ARE TWO BOYS WITH SAM.
    >> THE BOYS ARE FRIENDS OF SAM'S, AREN'T THEY?

  8 . THE BOYS ARE FRIENDS OF -----, AREN'T THEY?              ? HIS
        YES.
```

Here "context" sentences like <u>THERE</u> <u>IS</u> <u>A</u> <u>GIRL</u> <u>WITH</u> <u>JANE</u> establish contextual antecedents for the exercise sentences requesting possessive pronoun decisions since nouns like <u>girl</u> appear in the exercise sentences without identifying prepositional phrases. The syntax of the exercise sentences is varied, there being one declarative and three interrogative forms used:

THE BOY IS A PARTNER OF TOM'S.
IS THE BOY A PARTNER OF TOM'S?
ISN'T THE BOY A PARTNER OF TOM'S?
THE BOY IS A PARTNER OF TOM'S, ISN'T HE?

In summary then: (1) For many aspects of language arts CAI simulated contextual situations can be provided that are far more dynamic than the static exercises of a traditional textbook. (2) The student himself develops many of these contextual situations. (3) Thus, a most careful study and control of the subject matter is demanded of and must be preplanned by the CAI developer. (4) The terminal, through dynamic interplay, can prove far more powerful than a customary textbook, though obviously not so flexible nor as dynamic as an adept classroom teacher. And (5) the adept teacher with adept CAI, one might note, ought to compose a far better team for the instructional environment than the teacher with just a static textbook.

Bud Sanders
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TELEMATH

ABSTRACT OF PROGRAM

INTRODUCTION

Project TELEMATH represents a cooperative endeavor between an electronics manufacturer (Gremlin Industries) and the San Diego Unified School District to develop and test a computer-based instructional system which will be within the budget capabilities of most schools. The equipment consists of a self-contained, compact micro-computer which delivers district-written mathematics curriculum via a standard television set. The computerized video-graphic system is designed for small group instruction to improve all basic skills in mathematics. Activities have been written by school personnel to reinforce each of the district's instructional math objectives from Level 3 through Level 8.

GOAL

The major goal of the project has been to evaluate the effectiveness of a computerized video-graphic system in improving basic mathematics skills.

INSTRUCTIONAL STRATEGY

Fourth and fifth grade students from eight elementary schools (six public and two non-public) participated in the first year of the project. The second year has seen the involvement of students in grades three through six. Students received their regular mathematics instruction, less two half hour periods per week when they were pulled out in groups of two to four to use the TELEMATH system. Activities were programmed into the computerized video-graphic system based on the students diagnosed needs. Drill and practice activities appeared on the television screen and students interacted with the computer by operating hand-held, controlled keyboards.

An attempt has been made to maximize student motivation by combining, (1) a micro-computer, (2) a television screen and (3) a personalizing link between equipment and student. Personalization was accommodated by referring to individual students by name on the screen throughout each activity. Immediate feedback to individual responses enhanced the personalization.

FUTURE IMPLEMENTATION

During the third year, students in grades K through 8 will have the benefit of receiving instruction via TELEMATH in all basic skill areas in mathematics.

THE PLATO BASIC SKILLS LEARNING SYSTEM:
GOOD NEWS FOR FUNCTIONALLY ILLITERATE ADULTS

Presented by:

Patricia M. Mullinix and Peter J. Rizza, Jr
of Control Data Education Company
and Ralph T. Heimer of The Pennsylvania
State University

Program Implementation

In February, 1978, an adult learning center opened in Baltimore under the joint sponsorship of business (Commercial Credit Company) and government (Mayor's Office of Manpower Resources). In searching for a major Corporate Social Responsibility (CSR) activity for 1977 through '79, Commercial Credit Company decided to combine its business resources and expertise in computer-based education to the benefit of some of the many functionally illiterate adults within Baltimore. The creation of this center was motivated by a desire to offer an innovative and exciting educational program to residents of the area who lacked the basic skills necessary to compete in the job market. Commercial Credit agreed to provide a PLATO facility that would accommodate fifteen students at one time and from which students would have access to the Control Data Basic Skills Learning System.* Such a facility required ten PLATO terminals to be financed through CSR funds. The Mayor's Office of Manpower Resources (MOMR) agreed to refer to the center clients who were eligible for CETA programs (Comprehensive Employment and Training Act), and in need of this training.

The center opened with thirty students who spent two hours per day, five days a week, in Basic Skills study and approximately five hours per day in a clerical training program. Within five months, the center had extended its program to a sixty-hour week and was accommodating approximately one hundred eighty clients, young adults not in school and older adults ranging into their fifties. Many of these people received job release time two hours per day for two or three days per week for their study. Others attended on their own time. The group assigned to the PLATO room always contained a maximum of eighteen adults for a two-hour time period. The clients had access to the complete courseware package for all three curricula, reading, math, and language skills. This included on-line tutorials, practice exercises and tests, as well as off-line skill booklets and videotapes.

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*The Basic Skills Learning System is a curriculum designed to enable learners with a wide range of abilities, goals and problems to achieve an eighth-grade level of competence in reading, math and language skills.

Upon entering the program and again upon completion, each client was administered an attitudinal survey to determine attitudes toward learning in general and toward specific subject matter or topics. Also, using the Adult Basic Learning Examination (ABLE), Level II, each individual was pre and post-tested in the areas of reading comprehension and mathematics computation and problem solving. Data was kept relating to attendance and amount of time spent in instruction by each student, as well as the growth data in achievement level and attitude just mentioned.

Because the program began just this past February, by July there were not yet large numbers of students who had completed the entire Basic Skills Learning System. So that achievement results might be based upon a reasonably sized population, students who had been in the program a substantial length of time (at least three months) were post-tested regardless of whether or not they had completed all courseware. Some had completed one curriculum, but had worked very little in the other; others had progressed significantly in both reading and mathematics, but had completed neither. A total of fifty-two clients were post-tested at the end of June. However, data was included in the analysis for a curriculum only if the student's entry level indicated he/she needed further study in that area (entry level below 8.5 grade level) and only if the student had actually begun PLATO study in the curriculum.

Achievement in Reading

A total of twenty-four students formed the basis of the analysis in reading comprehension after being post-tested using Level II, Form B, of the ABLE. The mean growth rate for these twenty-four adults, expressed as a grade level equivalency was 0.8 for approximately fifteen hours, on the average, spent in PLATO instruction on the reading curriculum. Even if that time is generously increased by 50% to account for the additional hours spent by students with off-line materials, the total time committment of the student was still less than twenty-three hours for gains that would be expected from an average school student in eight months or approximately 120 instructional hours.

Reading

Grade Level Gain	Time On PLATO	Estimated Total Study Time	School Student's Time For Similar Growth
0.8	15 hours	23 hours	120 hours

Table 1

Isolating data of students who had completed the reading curriculum before taking the post-test also shows a mean grade level growth of 0.8 for eleven students, for approximately 18.5 hours per student. The entry levels, according to ABLE, Level II, Form A, of these eleven students varied from 5.8 to 8.4, again expressed as grade level equivalents, with a mean of 7.0. The range on the post-test upon completion of the curriculum varied from 6.1 to 9.0+ with a mean of 7.8. (The "+" recorded with a ninth grade equivalency is indicative of a proficiency above ninth grade level. This is necessary because level two of the ABLE is designed to measure only third through ninth grade material.) Two students, or 18% of those completing the reading program, achieved this 9.0+ score. Five students, or 45% of these adults, achieved the goal of completing with a reading level of eighth grade or better.

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Achievement in Mathematics

In the areas of mathematical computation and problem solving, forty-nine students formed the group whose scores were analyzed. The mean growth rate for these forty-nine adults in mathematics was 1.2 grade levels. The average on-line time for a student in this group was slightly less than twenty hours. Increasing that by 50% again, to allow for time spent with skill booklets and other mathematics study, results in approximately thirty hours of time required by the student to obtain the equivalent of over one year's growth. This is comparable to the average school student's growth during approximately 180 instructional hours.

Mathematics

Grade Level Gain	Time On PLATO	Estimated Total Study Time	School Student's Time For Similar Growth
1.2	20 hours	30 hours	180 hours

Table 2

Isolating data of just the adults who had completed the math curriculum, left a total of twenty-two students with a mean growth rate of 1.8 grade levels for approximately twenty hours of PLATO instruction. Grade level equivalencies upon entry varied from 4.7 to 7.6 for these twenty-two, with a mean entry level of 6.3. Growth rates from pre to post-test varied from 0.3 to 3.4 grade levels, and upon completion grade level scores varied from 6.0 to 9.0+ with a mean of 8.0. Five adults, or 23% of the completers, were above ninth grade proficiency; and fourteen, or 64%, achieved the desired proficiency level of eighth grade or better.

Attitude and Other Results

Students have expressed much enthusiasm for this program. Absenteeism and drop-out rates have been low in comparison to other such adult programs. Daily attendance rates consistently averaged better than 70%.

The majority of the students that left the program had personal problems such as illness or child care difficulties, or had job changes that no longer permitted them to attend. Many of these expressed an interest in re-enrolling at a later date. As of July 1, the total rate of attrition, counting all students withdrawn from the program for any reason, was 23%. Counting just those who were dropped from the roll because of poor attendance and those who terminated themselves because of lack of interest, the drop-out rate was slightly less than 6%. At least three students, who obtained permanent jobs and left the CETA funded position that provided them released time for study, came back to the center in the evenings, after a full day of work, to complete the Basic Skills program. Another student who completed the Basic Skills courseware and moved on to a more traditional G.E.D. preparatory class, came back and asked why the G.E.D. program wasn't available on PLATO also.

Results of the attitudinal survey completed by students at the end of their program also indicated a positive feeling toward basic skills study via PLATO. Based upon twenty-one respondents, 90% stated that they liked learning with PLATO always or most of the time. 90% said that PLATO lessons were never or seldom too hard. 81% felt that always or most of the time, PLATO was an easy way to learn. PLATO is never or seldom boring according to 81%.

Following are some of the comments made by students on this attitude survey form in response to an open-ended question asking for their reactions:

(1) "I like PLATO. It taught me about punctuation. I didn't know anything. It helped me to better myself in a lot of ways that I can't tell."

(2) "I like PLATO because of its individual teaching, its short and simple methods of explaining problems. Also, I like PLATO because it will not let you move on to another cluster without mastering what you don't already know."

(3) "I really liked PLATO because of the way it explains things to you. There are things in each subject that I never understood in school or when someone explained it to me, that I understand completely thanks to PLATO."

(4) "PLATO is a good way to learn if you are a slow learner. It can take you step by step and help you without you feeling stupid."

(5) "I like PLATO because I can progress at my own rate. Problem areas were always explained. I knew NOTHING about geometry before PLATO, and now I know the basics."

Before the end of October, 1973, other significant results were also apparent. Thirty-seven of the clients had received certificates of completion for having progressed through all units in all three curricula of The Basic Skills Learning System. Ten students who had also completed the nine month clerical program had received full-time jobs in the clerical field. Four G.E.D. diplomas had been awarded, and two students had gone on to enroll in college level courses.

Concluding Comments

For these students, growth in reading seemed to progress at a fairly constant rate throughout the program. It could be projected that on the average, a student might be expected to increase reading comprehension by a grade level for a time investment of approximately twenty hours on PLATO, plus some off-line study.

Growth in mathematics, however, did not show a steady rate of increase as the students progressed through the nine strands of study. There were sixteen students who had not completed strand six on fractions when they were post-tested. The mean gain in grade level for these sixteen adults was only 0.3. Comparing this to the 1.8 gain of the twenty-two students completing the curriculum indicated that the most substantial growth had occurred as the student completed fraction work and moved through the decimal and percent problems of the later strands. It should not be inferred, however, that these early strands are unnecessary. A specific study would need to be undertaken to determine this, but it may well be that students need the reinforcement of simpler skills provided in the early strands as foundation for progressing.

It might also be predicted that students in the future would show even greater gains than did this group. Although these students were given credit for completing the math curriculum, they did not in fact receive the complete program. A series of on-line application problems had been designed to accompany each strand, but were not being incorporated by the early form of the router. These application exercises related closely in concept to the problem solving subtest of the ABLE. The additional exercises would only slightly increase the time required of the student, but could substantially increase his/her confidence and ability in attacking mathematical word problems.

The clients coming through this center are people that have been frustrated by past educational experiences. Often they left school because they felt they weren't learning anything, and some felt they couldn't learn. Self-images were frequently very low with individuals thinking of themselves as "slow" and "stupid". The Adult Learning Center has provided a new opportunity for these people to increase their skills and to enhance their self-concepts. Being able to understand what is read, to fill out an application, or to get a better job is no longer just a remote dream for some of these Baltimore residents, but has become a reality.

A MULTI MEDIA APPROACH TO A SURVEY COURSE: INFORMATION PROCESSING AND THE COMPUTER

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Information Processing and the Computer: A Survey is a course that has been offered by Mercer County Community College for ten years. During that period of time the mode of instruction, the content of the course, and methods used in presentation have been varied. The change to the multimedia approach has been gradual during this period of time as opposed to a complete change from some other format. The current course media consists of 15 half-hour video tape components - one for each unit, a study guide geared to the instructional objectives for the course, including detailed objectives, tests for each unit, and a testing system.

General Objectives: The course is designed to introduce students to the basic concepts pertaining to information processing while at the same time providing them an opportunity to analyze and discuss the impact of computers on society. At the end of the course, students will demonstrate a mastery of basic terms and concepts in information processing. They will also be able to use flow charting techniques for problem solving and to write simple computer programs using a high level language. Students who successfully complete the course will have a good overview of information processing methods and technology. Understanding information processing is essential for grasping what happens in our technological world. This understanding is particularly useful for most of us who come in contact with computer technology in our working and daily lives. It is hoped that this course will generate both an understanding and appreciation of information processing, both of its problems and its manifold applications to social problems.

Five units make up one module of the course (one-third of the course). Three modules and their units for the course are:

MODULE I - Information Processing In Society - Background and Orientation to Computers

Unit 1. Information Processing
Unit 2. History and Evolution
Unit 3. Computer Concepts
Unit 4. Computer Input/Output
Unit 5. The Central Processor and Storage Devices

MODULE II The Computer As A Tool

Unit 6. Numbering System
Unit 7. System Studies and Programming Analysis
Unit 8. Program Preparation
Unit 9. Data Management and Operating Systems
Unit 10. Information Revolution

MODULE III - Additional Hardware Considerations: Economic & Societal Implications

Unit 11. Computers in Business
Unit 12. Computers in Government
Unit 13. Computers in Education
Unit 14. Computers in Science and Humanities
Unit 15. Information Revolution - The Future

In addition to the TV component and the Study Guide, there are handout sheets explaining the two modes of testing for the course, the schedule for the seminar hours (2 each for every unit in the course), and reading assignments currently keyed to two of the most popular texts for this kind of course.

The texts are:

Computers in Society
Author: Sanders
Publisher: McGraw-Hill

Computers and Society

Authors: Rothman and Mossmann
Publisher: S.R.A.

The TV Component of this course is geared to the objectives for each unit. TV has worked out to be an excellent medium for this purpose. Previously this was done in a large group lecture. However, few films and other types of media are available for use in large group lecture in this field because it is:

a. new, and
b. rapidly changing

The ability to show graphically with moving pictures has allowed us to demonstrate to the student many components of computer hardware and applications that could never be shown in a large group lecture. Since this is a rapidly changing technology the TV scripts were planned with the idea in mind that they would have to be replaced after a period of a couple of years. It was relatively easy to gauge that this would be necessary and how frequently by the changes in the course outline in the past years.

The Study Guide Component of the course was designed to assist the students, both on the campus and taking the course by public broadcast to have the specific information as to how to complete each unit. Additional material is sent to students taking the course off campus. The students on campus are given this material after viewing the video tapes but the student taking the course over public broadcast does not have this available so additional letters are sent to these students. In the Study Guide, in addition to detailed objectives per unit and the synopsis of the TV program, additional learning packets are listed. For example - the option to attend the demonstration of keypunching and getting a more concrete view of Hollerith Coding and the use of punched cards or Computer Aided Instruction packets available on the Mercer County Community College terminals for binary arithmetic and numbering systems. Currently, additional learning resources exist for about five of the units in the course. It is the intention of the faculty in the Department of Mathematics/Physics/Computer Science at Mercer County Community College to add to some of the learning resources available for the current units and to include more units in the future. Sample objective tests with the answers are also included with each unit.

There are two modes of testing available for this course. Both include a final examination. One mode is objective testing using mastery; the other mode is essay testing at the end of each module.

The mastery testing is arranged in the following way.

Please see Appendix 1.

The student may take the weekly tests a maximum of three (3) times. Each version of the test the student would receive would be different since the tests are computer generated. The student takes his test in the Testing Center at the College. After the test is taken it is graded immediately by an on-line computer testing system and the student knows whether they have reached mastery or not. If the student has not reached mastery, the student receives a prescription keyed to the objectives of the unit for the questions the student missed on the test. Most students do not reach mastery on the first attempt of the test and must attend scheduled seminars. Even if students do achieve mastery on the first or second test attempt a large majority also attend the seminars. Seminars are planned to answer students questions and bring to the students different points of view, not demonstrated in the video component, study guide or the text books keyed for the course.

Students who take the course over Public Broadcast and elect not to attend seminars on the campus have the option of calling the instructor during specified times in the office or at their convenience. A Record-A-Call Device is attached to the instructor's (who is responsible for the course) telephone at Mercer County Community College. Students have availed themselves of this service and of the fifty-some students who took this course in this mode during Fall 1977 a good portion of them contacted the instructor multiple times during the semester to discuss a particular point or to get clarification on a particular objective.

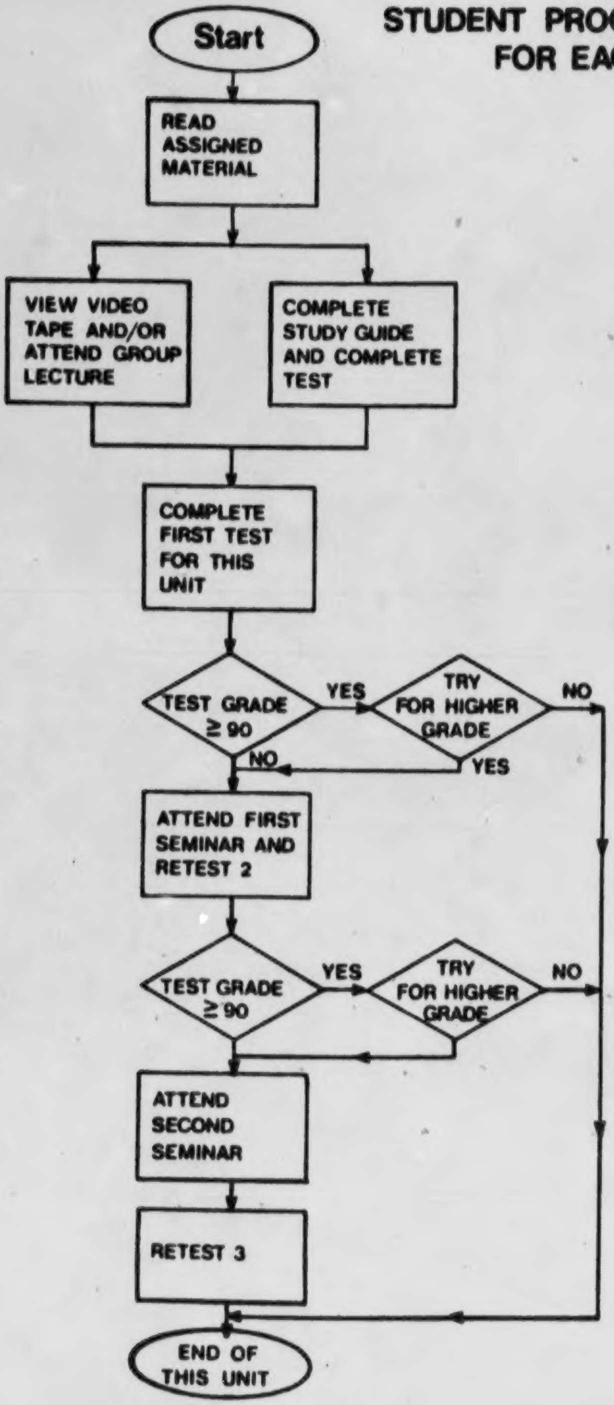
The Institutional Research Department at Mercer County Community College has put together survey instruments to be used with students in this course. The course TV component was piloted during Spring 1977 and students were surveyed. It was then instituted with the complete TV component during the Fall 1977 semester and again, students were surveyed. All surveys have not been analyzed as yet, but the initial feedback has been positive. Students like the TV component. The mastery grade level was increased between the Spring and the Fall semesters by five points and seminar attendance has improved dramatically.

The TV component, Study Guide and the Test Bank have been developed since the Summer of 1975. All of the Computer Science faculty in the department have given input to this project. However, Dante Masciantoni has been the prime person for the TV script working with the production TV department at Mercer County Community College and for the Test Bank working with the Testing Center at Mercer County Community College. I have worked with Professor Masciantoni during these 2-1/2 years on a daily basis providing input, ideas, and writing the study guides.

Attached you will find a sample study guide for one unit of the course (Appendix II). Now I would like to show you what a sample TV program is like.

APPENDIX I

STUDENT PROCEDURE FOR EACH UNIT


Start
READ ASSIGNED MATERIAL
VIEW VIDEO TAPE AND/OR ATTEND GROUP LECTURE
COMPLETE STUDY GUIDE AND COMPLETE TEST
COMPLETE FIRST TEST FOR THIS UNIT
TEST GRADE ≥ 90
YES
NO
TRY FOR HIGHER GRADE
NO
YES
ATTEND FIRST SEMINAR AND RETEST 2
TEST GRADE ≥ 90
YES
TRY FOR HIGHER GRADE
NO
ATTEND SECOND SEMINAR
RETEST 3
END OF THIS UNIT

APPENDIX II

MODULE II

THEME: THE COMPUTER AS A TOOL

INSTRUCTIONAL UNIT 10. Information Revolution: Its Setting and Effect

OBJECTIVES FOR THIS UNIT:

After completing this unit, you will demonstrate your knowledge of the Information Revolution by being able to:

1. List changes and developments that stimulated the need for better information.
2. List factors needed for improved information.
3. List advancements in computer technology in both hardware and software.
4. Describe the components of a total system - Computer Base Information System.
5. Describe a Quick Response System.
6. Describe and give examples of various kinds of networks.

TERMS YOU SHOULD KNOW AS USED IN INFORMATION PROCESSING:

- Batch processing
- Data communications
- Data transmission
- REAL-time processing
- Direct access
- Transactions

TELEVISION PRESENTATION: The Information Revolution in The Future

This program is designed to provide you with the kinds of computing that will be available during the 1980's. Points covered:

1. The advances in storage devices, bubble memories, direct access storage devices, laser memory, intelligent terminals, mini and microcomputers and their impact are shown.

2. How these technologies will impact on our lives is demonstrated by the effect they will have on our leisure, how car servicing will be handled, how robots will do many tasks, how our current post office will be obsolete, how the health field will be rapidly changed.

3. In general it is an extrapolation into the next decade of the knowledge and technology available today.

DP 103

SAMPLE TEST

TRUE/FALSE

___1. Since the computer has been used to replace clerical help it is thus directly responsible for high unemployment rates.

___2. Software is a term used to describe articles of clothing, bedding, draperies, etc.

___3. Computer benefits are always classified as tangible (dollar and cents value can be assigned).

___4. Those computer benefits that are not subject to quantitive measurements are said to be intangible.

___5. Computer usage may have economic benefits by cost displacement improving operations and revenue improvement.

___6. Revenue minus expenses = profit.

___7. Increase in revenue always results in an increase in profit.

___8. An organization will always benefit with the use of a computer.

___9. It is frequently most economical to use a computer for repetitive projects.

___10. The need for timely information is a desirable characteristic for computer processing.

___11. Computer processing has greater accuracy if the task has been properly prepared.

___12. Paper work volume is increasing and the computer thrives on repetitive and large volume tasks.

___13. Quality and Accuracy are not synonymous.

___14. Five factors needed for improvement of information processing are increased volume, demand for timeliness, quality, outside social and economic changes and costs.

___15. A computer is used most efficiently if small amounts of data must be processed.

___16. Pressures for information improvement have not increased in the last decade.

___17. The simultaneous handling of multiple programs is referred to as simulcast.

___18. The instructions prepared for one machine can always be used on another machine.

___19. A single computer system has modular capability if it can grow.

___20. Large Scale integration produces lower costs.

___21. Compatibility means hardware that looks alike.

___22. Urban decay, air pollution, increase in crime and unemployment are all social and economic changes that demand a need for better information.

MULTIPLE CHOICE - circle the best answer

23. Which of the following has not contributed to awareness of the need for information improvement:

    a. increased paper work volume
    b. demand for timeliness
    c. demand for quality
    d. pressures from environmental changes
    e. reduction in data processing costs

24. Managers need information to:

    a. establish, evaluate and adjust goals
    b. develop plans and standards and initiate action
    c. measure actual performance and compare this performance against standards
    d. perform A, B and C
    e. keep information processing departments busy

25. Information is meaningful if it meets the following requirement:

    a. accuracy, timeliness
    b. completeness, relevancy
    c. conciseness
    d. A and B
    e. A, B and C

AN EVALUATION OF COMPUTER-BASED CLINICAL CASE HISTORIES IN HEALTH SCIENCES EDUCATION*

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Abstract

This project evaluated the use of computer-based materials that were supplemental in Pharmacology 100 A (2nd year medical students) and Pharmacology 125 (2nd year pharmacy students). 204 students signed consent forms to participate in the evaluation. The two subject areas evaluated were organophosphates and digitalis toxicity.

Students were randomly assigned to three treatment groups; (1) computer-based education; (2) a written booklet with review questions; and (3) a control group. Midway through the course, after the evaluation materials on organophosphates were distributed to the appropriate treatment groups, students received a posttest.

Toward the end of the course the students were again randomized in a second experiment and then were given evaluation materials in the second area, digitalis toxicity, according to their treatment group (computer, booklet or control). Again a posttest was administered. A two-way analysis of variance was computed for each of the subject areas evaluated.

The analysis for the first subject area,

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*Research performed at the University of California, San Francisco health sciences campus

**IBM, Data Processing Division, 525 University Ave., Palo Alto, Calif. 94301 organophosphates, revealed a significant difference ($p<.05$) between the different treatment groups. A multiple classification analysis demonstrated higher mean scores for the computer group as compared to the two other groups. An a-posteriori contrast (least-significant difference) computed for the three treatment groups shows a significant difference ($p<.05$) between the computer group and the control group. The two-way ANOVA also showed that as a group medical students did significantly better ($p<.01$) than pharmacy students in the same subject area.

The analysis for the second subject area, digitalis toxicity, revealed no significant difference between treatment groups, although medical students still did significantly better as a whole ($p<.01$) than pharmacy students in the subject area.

Two evaluative experiments, no matter how diligently administered, cannot yield enough information to establish an enduring protocol for the delivery of computer-based education. However, this research does indicate that computer-based education can significantly increase posttest scores in specific topic areas.

Introduction

The goal of this research was the development of a realistic protocol to evaluate the use of CBE (computer-based education) at the University of California health sciences campus in San Francisco.

Because CBE was not utilized as the central resource for any course at the university, it seemed important to evaluate CBE in actual use on this campus, which was as an adjunct to a course. With this in mind, a research design was developed to analyze CBE within the constraints of ongoing classroom instruction.

Methods

The experimental groups participating received the following treatment conditions in specific subject areas: (1) computer-based education as a supplement to traditional instruction; (2) a printed instructional booklet with review questions, again as a supplement to traditional instruction; and (3) traditional instruction (the control condition). These three treatment groups were presented with materials in two different areas, organophosphates and digitalis compounds. Results were analyzed as two separate experiments. Two classes were used, medicine (U.C. code: Pharmacology 100A) and pharmacy (U.C. code: Pharmacology 125).

Participating students were randomized into three groups for Experiment I on organophosphates. For Experiment II later in the course using materials on digitalis, each of the three treatment groups were divided into two by using a random number sequence, and then the six groups were recombined into three groups such that each participant would be in a different treatment condition for the second experiment than they were in during the first experiment. The total sample size for both classes was 204 students.

Results

After all the test scores were recorded and the students surveyed as to their opinions of CBE, analyses were performed on the data. Two main areas were looked at for specific results. They were: (1) scores on the students' posttests, both the general exams and the specific evaluation questions. These scores would determine the student's retention and comprehension of the supplemental materials used in the study; and (2) the attitude survey of how students viewed CBE and the supplemental learning materials.

The first area measured was student retention and comprehension of the supplemental materials. Four analyses of variance (ANOVA) were performed.[1] They included ANOVAs of the (1) evaluation questions on the organophosphate area analyzed by the three treatment groups (CBE, booklet, and traditional instruction);

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[1] All analyses performed used programs found in "Statistical Packages for the Social Sciences", 2nd Ed., N. Nie, et. al., McGraw Hill, New York, 1975.

(2) an analysis of the first exam by the three treatment groups; (3) analysis of the evaluation questions on the digitalis toxicity area by the three treatment groups; and (4) an analysis of the second exam by the three treatment groups. Also, an analysis of covariance (ANCOVA) was performed on both evaluated areas using the general exam given at the same time as the covariate. Subjects were also coded by class, medicine or pharmacy, in order to determine any significant interactions. The independent variables in the ANOVAs and ANCOVAs were the treatment groups and the different classes (medicine or pharmacy), while the dependent variables were the scores on the students' examinations.

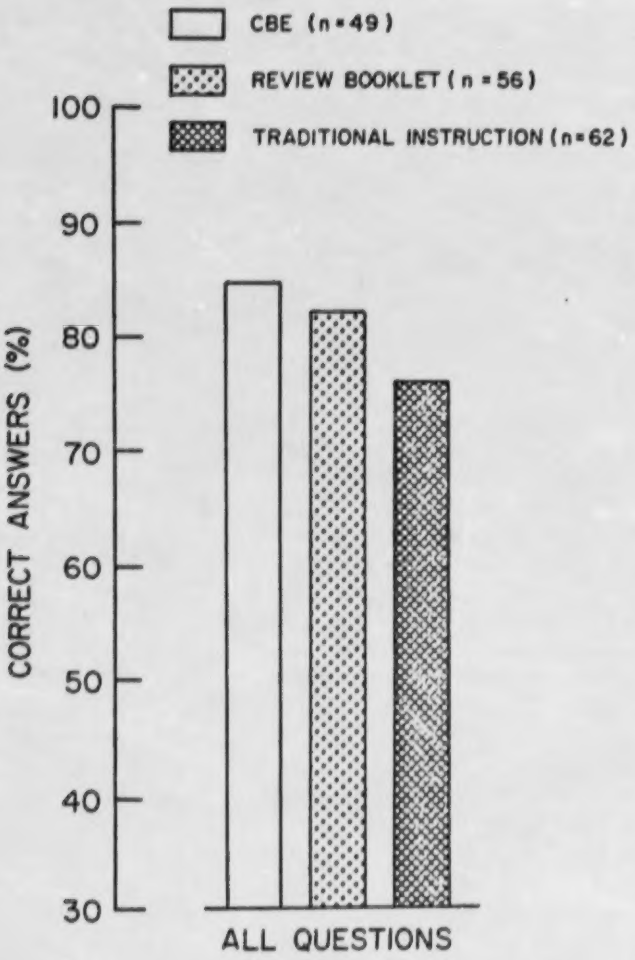
The following were the results of the analyses. The first of the analyses was the students' test questions on the clinical case histories dealing with organophosphates. The results demonstrate some significant effects. The main effects for the ANOVA are significant, $p<.01$. The treatment effect among the three groups is significant, $p<.05$, and so is the difference between the two classes, medicine and pharmacy, $p<.01$. However, the two-way interactions between the treatments and the two classes are not significant, and therefore separate analyses for the individual classes were not performed.

The multiple classification analysis indicates that the CBE group had the highest mean scores, followed by the booklet group, and then the traditional instruction group.

Since there was a significant difference among treatment groups in the area of organophosphates, an "a-posteriori contrast", least-significant difference, was computed. The results using ranges at the .05 level indicates significant differences both between the CBE group and the other two treatment conditions. Significant differences were also found between the CBE group and the booklet group, compared to the traditional instruction group. A bar graph of the three groups using percent correct responses (Figure 1) visually shows the differences between the three groups with the CBE group scoring highest, the booklet group next, and the traditional instruction group third.

Figure 1

Results by Treatment Group Showing Percent Correct Answers, Evaluation Examination, Organophosphates (Experiment 1)



An ANCOVA was performed using the general exam as a covariate. The results substantiate the findings of the previous ANOVA, although somewhat more "fine-tuned" as a consequence of using general testing abilities in the analysis. Treatment group differences become sharpened to a significance level of .037 rather than the .05 level found in the ANOVA.

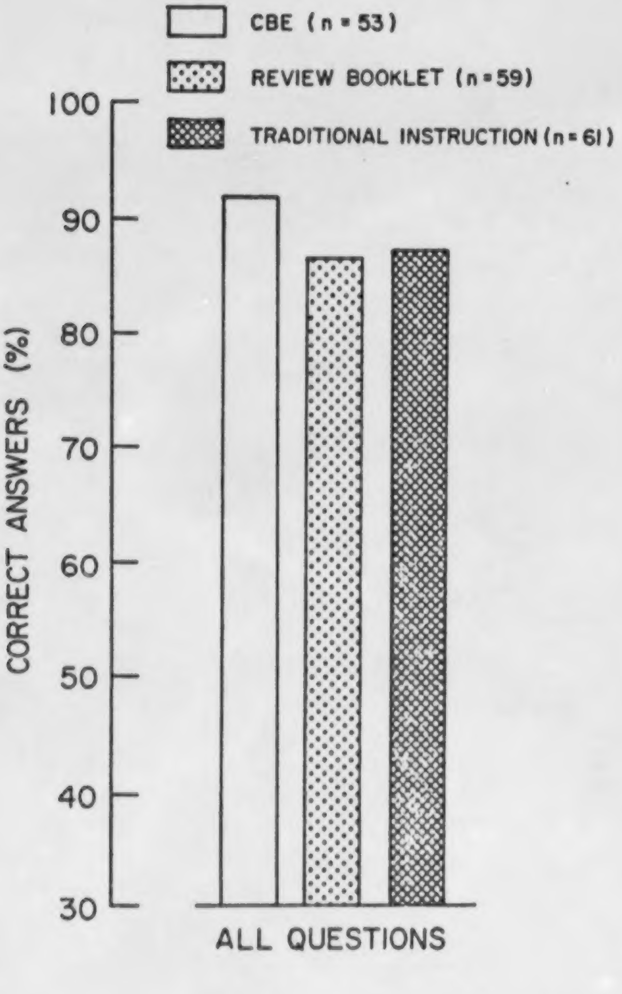
Since it was important to know how the students did in their overall exams, in which the evaluation questions were embedded (without the student's knowledge of which were exam questions and which were evaluation questions) a general analysis was performed on the exam results. An ANOVA showed no significant differences in the main effects for treatment or class. A multiple classification analysis also showed practically no deviation between the three groups from the mean.

The results so far indicate that there were significant differences among the three treatment groups in the area of organophosphate materials, with the CBE group doing best and the booklet group next best. However, no significant differences among the groups were observed on the general exam given at the same time. The results would indicate that the student's assignment had a significant bearing on scores relating to the retention and comprehension of the specific materials covered in the CBE and booklet.

During the latter part of the quarter the experiment was repeated in the area of digitalis toxicity. Again an ANOVA and multiple classification analysis were computed. The ANOVA confirmed significant differences for the two classes, medicine and pharmacy, but not among the treatment groups. Again, as in the first experiment, there were no two-way interactions between the treatment conditions and the classes. The multiple classification analysis indicated that the CBE group was highest in mean scores, this time followed by the traditional instruction group and then the booklet group. A graphic representation of the scores is found in Figure 2. An ANCOVA performed using the general exam as a covariate still did not demonstrate significant differences among treatment groups.

Figure 2

Results by Treatment Group Showing Percent Correct Answers, Evaluation Examination, Digitalis (Experiment 2)



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Again, the same two analyses, ANOVA and multiple classification analysis were computed for the classroom exam in which the test questions were embedded. The results demonstrated no significant differences between the treatment groups, but revealed a difference between the classes ($p<.01$). Also, there were no significant two-way interactions and therefore no discernible pattern between classes in the treatment effects. Since there were no significant differences in the second experiment, no "a-posteriori tests" were performed.

Students were also requested to fill out an attitude survey about their use of CBE in the classroom. Since these forms were optional, 101 of the 204 students, or 49% of the students who used the computer, filled them out. The total number of surveys received was 159; however, 58 of those did not use the computer. They may have been nonparticipants or only had been placed in the booklet or traditional instruction group.

The first question asked the subjects was whether they had used any of the computerized quizzes. 63.5% had used them, while 36.5% had not. Beside the two evaluation programs there were another six programs available to all students for a total of 8 CBE programs. The mean use among the respondents who used any CBE program was 4 programs. When queried as to how they would gauge the overall effectiveness of the CBE cases as a means of learning, on a value scale of 1 to 5 (1 being low and 5 being high) the mean score was 4.09. When asked how they valued the computerized case as an adjunct to the course on the 1 to 5 scale, the students' mean response was 4.27.

The students were also asked if they "enjoyed using computerized learning materials." Of the 101 respondents who used CBE, 93% agreed with this statement, while only 7% were indifferent or disagreed.

Discussion

There are two major areas for discussion of this research, one being the strengths and weaknesses of the experimental design and methodology; the second the interpretations that can be derived from the experimental results.

The experimental design developed used the resources that were available. Since this evaluation took place during an ongoing course there was little that could be done to alter the experimental variables. Therefore a design based on the investigator's ability to manipulate all the independent variables was not possible. The design used was basically a posttest only, control group design, with the added feature that the treatment groups had non-isolatable factors in common with the control groups.

The research performed looked at two different subject areas, organophosphates and digitalis compounds. In both areas the students did better with the computer-based materials, and the written review booklets, when their mean test scores are compared to the traditional-only instruction group. However, only in the area of organophosphates were statistically significant results seen for the students with optional learning materials. Why was this result observed only in one of the experiment subject areas?

In looking at the two separate experiments (organophosphates and digitalis compounds), two differences are readily observed. These are first, the complexity of the materials presented, and second, the time sequence in which the materials were presented to the students. The area of organophosphates was the less complex of the two. The clinical case history used was a straight-forward example of parathion poisoning with no complications. The digitalis case, conversely, was considerably more difficult requiring extensive knowledge of various digitalis compounds and their antidotes. The difference in complexity can also be verified by the fact that the digitalis computer program has over twice the amount of lines of computer code than the organophosphate program. The over-double length was needed because of the sizeable amount of branching strategies used to meet all the different possible student responses.

Why would material considered simpler (the organophosphate case) give significantly different scores between experimental groups, while the more difficult material (the digitalis case) not be significant among groups? It was expected that the converse would occur, since among a large group of students, supplemental learning materials were assumed to make a considerable difference as the complexity of the materials increased. Yet the opposite was observed in this case. One possibility is that in the beginning of the course, before grade pressures start, studying may be more haphazard. The organophosphate material may have encouraged those experimental groups who had the supplemental cases to be more conscientious than the traditional instruction group. Or conceivably, organophosphates is a less interesting subject than digitalis compounds. Students perhaps focused less on organophosphates and the groups receiving supplemental materials thereby benefitted from an increased attention to the subject.

Another point of interest is the time factor with respect to the application of supplemental learning materials. For instance, in this experiment the organophosphate program was used early in the course (and there were significant differences among groups), while the digitalis materials (no significant differences among groups) were given toward the tenth week of an eleven week course. One possible explanation for this difference is that in the beginning of a course students do not know which books are best or where to locate all the different course materials. Supplemental materials, such as CBE, gives those students who use it early in the course an advantage, while toward the end of the course students are more familiar with all outside resources and the advantage of the CBE and booklet materials fades.

In conclusion, the attitude survey indicates that CBE is well accepted by students as a form of instruction. Also, the results suggest that CBE materials might not be as effective for exam reviews as has been previously assumed on campus. Rather, when CBE is used as a supplement to a course it may be most effective when used as a motivational tool to interest the student in new specific study areas.

AN INSTRUCTIONAL DESIGN TECHNIQUE FOR DEVELOPING COMPUTER SIMULATIONS IN DENTISTRY

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Plato Project
College of Dentistry, University of Nebraska

Introduction and Overview

The College of Dentistry at the University of Nebraska-Lincoln started a Plato Project in Dental Simulations in June of 1977, under a grant awarded by the National Library of Medicine, with a commitment to develop thirty clinical simulations in several areas of dentistry in three years. The dental simulations were to be designed to examine decision making and problem solving skills in dental practitioners, including junior and senior students.

In the health professions, simulation is an especially important mechanism for assessing problem solving and decision making skills because of the nature of the learning task which addresses the taxonomy levels of analysis, synthesis and judgment.[1] The creation of a simulated patient management encounter with requirements for collecting data, making a diagnosis based on that data, and the selection of appropriate treatment strategies serves as an ideal learning or testing activity for the advanced level of skills.

The Plato system was selected as a vehicle for the UNL simulation project because of its ability to accommodate the multiple branching required to satisfy all the possible decisions a user could address in a complex, problem solving exercise such as a patient-dentist encounter, and because of the tremendous graphics and touch capability which it offers. The development of the actual simulations was to be accomplished by clinical faculty in various disciplines, each of whom would be assigned to the project on a ten percent basis. The schedule of development was integrally tied to visits by review panels of outside dentists. These factors made it imperative that the investigators decide how to facilitate the rapid development of content and provide a mechanism for authors (with a minimal background in computer applications) to develop quality instructional materials. The purpose of this paper is to share the approach which was developed to meet that objective.

Content Development

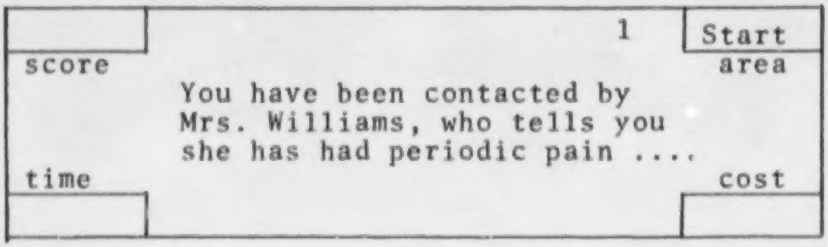
Much of the concept of developing and using written clinical simulations has evolved at the University of Illinois from the initial work of McGuire, et al.,[2] and using computer aided simulations from the basic work of Harless, et al.[3] Although there is an expanding body of literature developing which supports the value of clinical simulations for assessing problem solving skills, the references available for the actual process of designing and developing the content are limited. Two manuals which we have found most helpful to date are McGuire, Solomon and Bashook, *The Construction and Use of Written Simulations*,[4] and Vol. 7 of the Instructional Information Exchange for Dentistry in the United States which addresses the Measurement of Judgmental and Decision Processes.[5] These manuals describe methods of developing segments on cards or sheets of paper, and flow charting each segment for the optimal approach. Guidelines are presented for branching, bridging among segments, and scoring.

However, the development of computer simulations requires some adaptation of the methods described. Because of the complexity of the simulations, and the importance of flexibility for responding, moving about in the simulation without dead ends, and the multiple branching required, a simplified method of visualizing the structure of the content was essential. Aspects which were viewed as necessary to the soundness and completeness of the problem such as graphics for dental charting, palpation of muscles and tissues, realistic representation of the patient's dental arches (including restorations and missing teeth) needed to be easily conveyed to the programmer when the author was not readily available for lengthy consultation.

The initial approach was to construct a workbook which the author could use to outline the pertinent information for the case. Although the workbook served as an initial framework for what to include in the content, it became obvious very quickly that the need to generate the appropriate responses, indicate the branching, and recreate a decision pathway was not accommodated by the workbook. Attempts to chart the possible decision pathways through the construction of flow charts became clumsy and cumbersome, as dead ends in the branching required continual revisions of the flow charts.

The Coded Card System

A basic instructional design technique for developing script materials utilizes a storyboard approach with 4x6 file cards, which allows the author to write a single idea per card, and then organize the cards in a systematic fashion to create a flow and sequence for the material.[6] The Project investigators have used storyboards regularly in the development of slide tape programs. Expanding on this concept, a basic card was designed which could be used to write every sequence in the problem and every possible choice related to each sequence. (Figure 1)



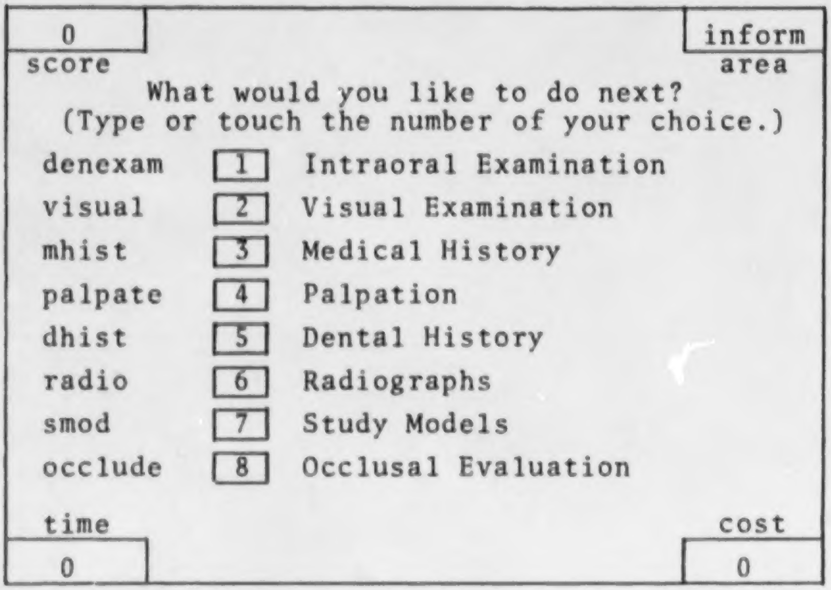
You have been contacted by Mrs. Williams, who tells you she has had periodic pain ....

Figure 1

The upper right hand corner of the card identifies the area in which the content belongs, and also becomes the name of the terminal display. The other corners are used to identify the evaluation data relevant to the material on the card. These data include the variables being used for scoring the decision, plus related time and cost, which will be used to determine the efficiency of the problem solver. The number assigned to the simulation is noted next to the "area" box. Thus, everything relating to the display is visible for the programmer, as well as the instructional designer and evaluator, who also need to work with the cards.

Area "codes" have been identified and standardized for each section of the content outline. The code names have been agreed upon with the senior programmer so that the transition from written cards to computer program is simplified. Anyone looking at sections or groups of cards knows immediately where they fit in the problem and where it can be seen as a terminal display.

The structure of the content for every simulation is divided into two major sections: data gathering and treatment. The data gathering section is preceded by the original contact or "start" statement and the treatment section is preceded by the identification of the problem area. Figure 2 shows a standardized selection page for collecting information in the data section.



0
score

inform
area

What would you like to do next?
(Type or touch the number of your choice.)

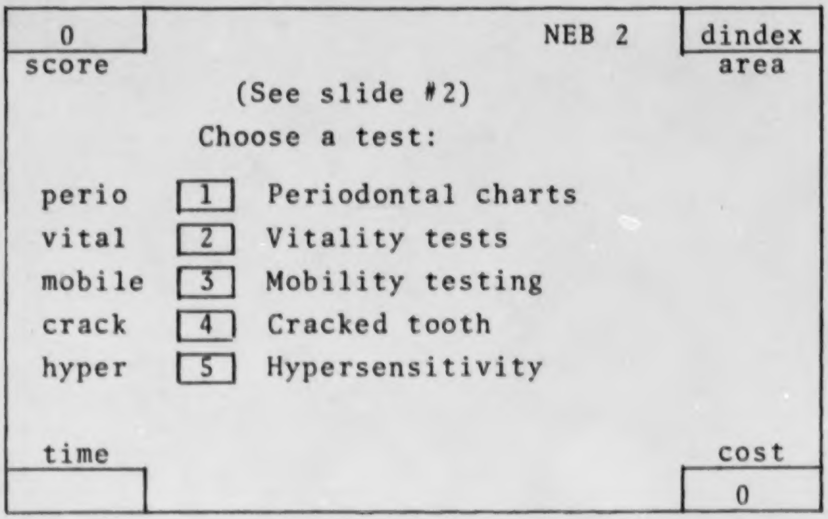
denexam	1	Intraoral Examination
visual	2	Visual Examination
mhist	3	Medical History
palpate	4	Palpation
dhist	5	Dental History
radio	6	Radiographs
smod	7	Study Models
occlude	8	Occlusal Evaluation

time
0

cost
0

Figure 2

Its code name is "inform." Each statement is numbered and then coded with an area name along the left side of the card to indicate the routing or branching to which it leads. The author will make out a response card for each choice, identifying each card with its area code name. Each response card then in turn, will be numbered and coded for branching in the same manner. Each section of "inform" contains several parts and the author must have information available in each part. These include such data as responses to dental tests: percussion, mobility, cracked tooth, etc.; measurements of dental charting, representational graphics of both dental arches including restorations, missing teeth, bridges, etc. Figure 3 shows the routing code for the intraoral exam from the "inform" page.



0 score

NEB 2

dindex area

(See slide #2)

Choose a test:

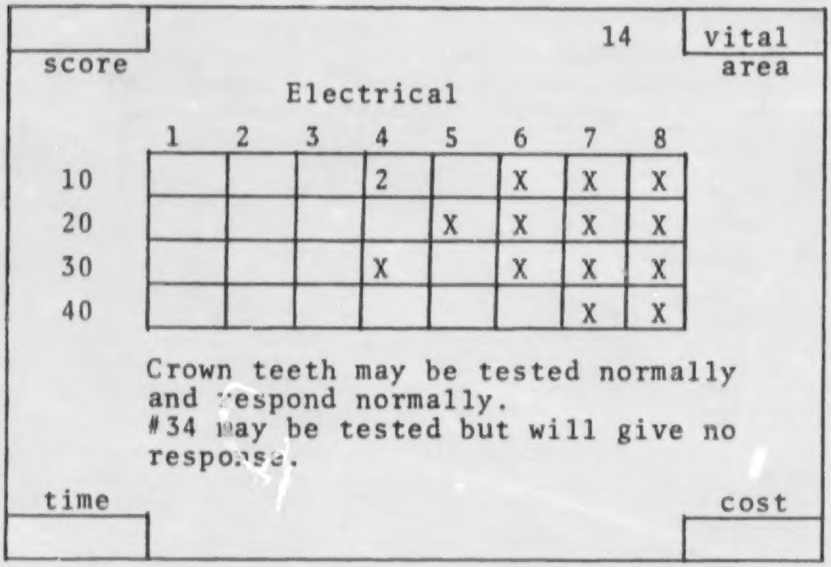
perio ☐1 Periodontal charts
vital ☐2 Vitality tests
mobile ☐3 Mobility testing
crack ☐4 Cracked tooth
hyper ☐5 Hypersensitivity

time

cost 0

Figure 3

Dental test responses are easily conveyed on special cards numbered to represent the teeth. (Figure 4)



Electrical

	1	2	3	4	5	6	7	8
10				2		X	X	X
20					X	X	X	X
30				X		X	X	X
40							X	X

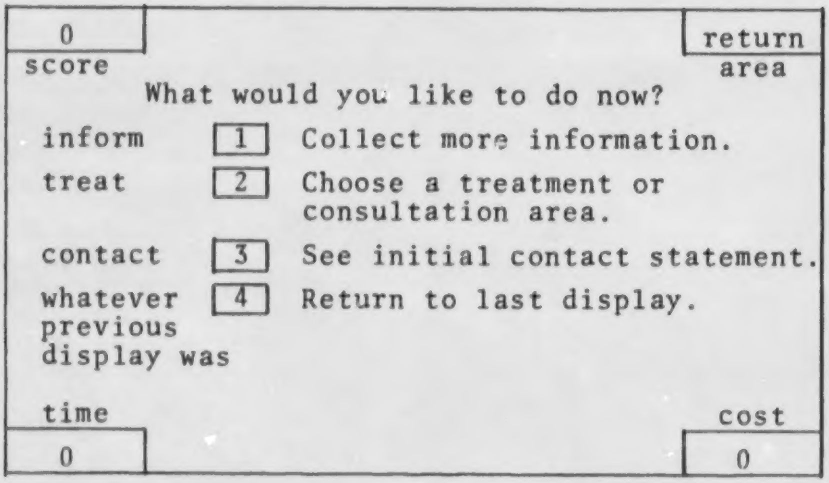
Crown teeth may be tested normally and respond normally.
#34 may be tested but will give no response.

Figure 4

The author can indicate for each test which teeth will respond, and what he wants those responses to be. Normal values are automatically programmed, so only those responses which vary from normal need to be marked. Missing teeth are noted with an X. With a card for each test, the programmer can easily translate the values.

Teeth charting and periodontal measurements are conveyed by marking the restorations and indicating the depth of pockets on a figure of the arches. The programmer can check the accuracy of his rendition of the graphic against a matching 2x2 slide.

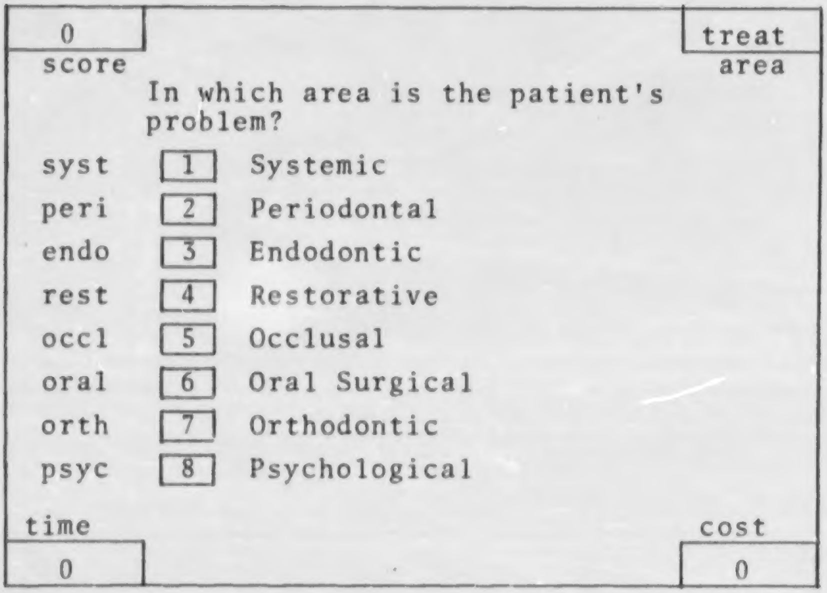
Several standardized responses allow for flexibility within sections and permit the user to move through the simulation more realistically. One such display is the "return" page as seen in Figure 5.



0 score		return area
	What would you like to do now?	
inform	1	Collect more information.
treat	2	Choose a treatment or consultation area.
contact	3	See initial contact statement.
whatever previous display was	4	Return to last display.
time 0		cost 0

Figure 5

Figure 6 shows the standardized diagnostic selection page identified as "treat", with the code name for each selection along the left side of the card.



0 score		treat area
	In which area is the patient's problem?	
syst	1	Systemic
peri	2	Periodontal
endo	3	Endodontic
rest	4	Restorative
occl	5	Occlusal
oral	6	Oral Surgical
orth	7	Orthodontic
psyc	8	Psychological
time 0		cost 0

Figure 6

Although each simulation has an ideal or "acceptable alternative" decision pathway and solution, the author must provide responses and choices in every section, in the event that a poor or wrong selection is made by the user. Authors find it easier to develop one pathway (usually the ideal one) and then subsequently develop the alternative pathways.

Using the area code for the section being developed, such as "peri" for the periodontal area, the author begins to develop and number selection statements, coding each statement along the left side of the card to indicate where it leads. In these sections, a series of letters is used in combination with the area code, such as peri-a, peri-b, and can extend as far into the alphabet as necessary to complete the section. He makes out a response card for each choice, identifying the card appropriately. When the section is complete, he can check the branching quickly and if he has left out any choices, can add cards immediately. Figures 7(A,B,C) and 8(A,B,C) show a brief example of this sequence.

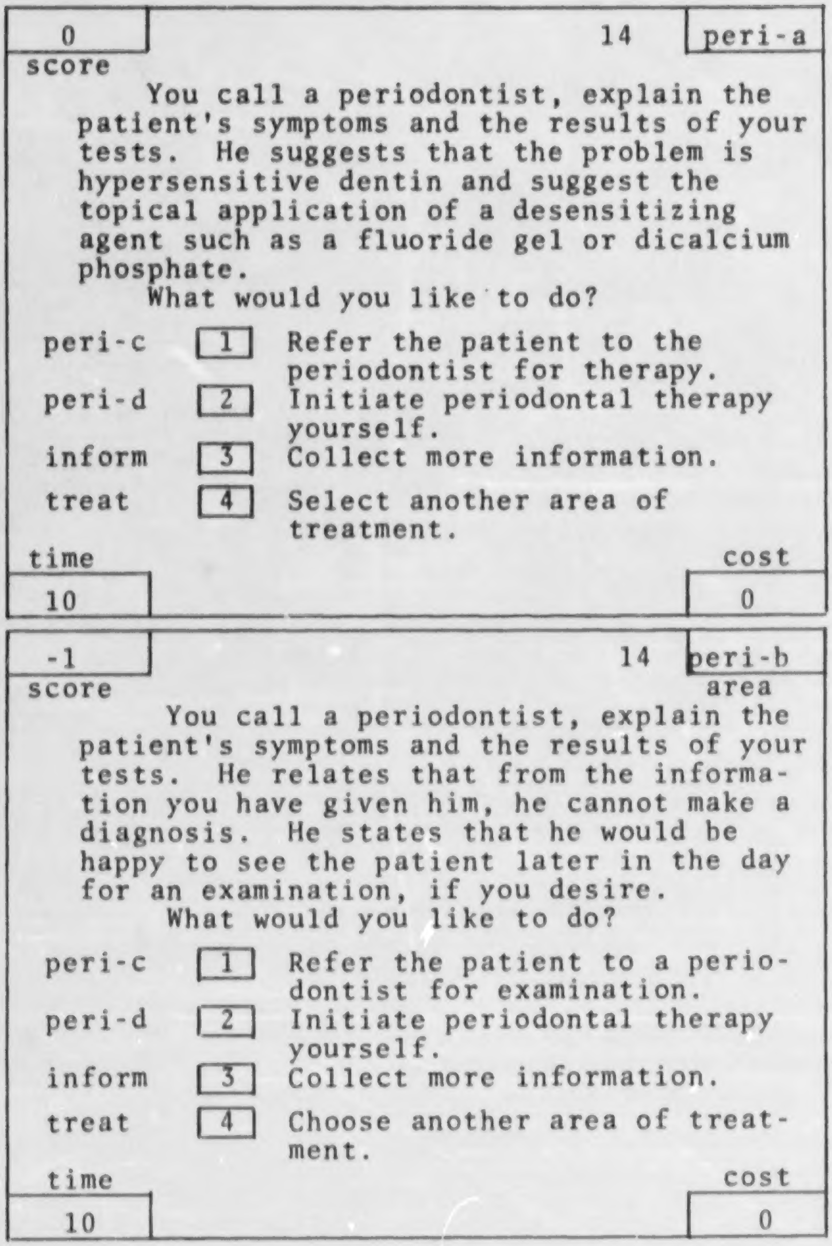
0 score	14	peri area

You have decided that Mrs. J's discomfort can best be treated by periodontal therapy. How would you like to initiate therapy?

	1	Consult a periodontist.
peri-a		if hypersensitivity tests have been run
peri-b		if hypersensitivity tests have not been completed
peri-c	2	Refer the patient to a periodontist.
peri-d	3	Initiate periodontal therapy yourself.
med	4	Prescribe medication.

time 0	cost 0

Figure 7A.



0 score
14
peri-a

You call a periodontist, explain the patient's symptoms and the results of your tests. He suggests that the problem is hypersensitive dentin and suggest the topical application of a desensitizing agent such as a fluoride gel or dicalcium phosphate.

What would you like to do?

peri-c	1	Refer the patient to the periodontist for therapy.
peri-d	2	Initiate periodontal therapy yourself.
inform	3	Collect more information.
treat	4	Select another area of treatment.

time 10
cost 0

-1 score
14
peri-b area

You call a periodontist, explain the patient's symptoms and the results of your tests. He relates that from the information you have given him, he cannot make a diagnosis. He states that he would be happy to see the patient later in the day for an examination, if you desire.

What would you like to do?

peri-c	1	Refer the patient to a periodontist for examination.
peri-d	2	Initiate periodontal therapy yourself.
inform	3	Collect more information.
treat	4	Choose another area of treatment.

time 10
cost 0

Figures 7B and 7C.

-1
score

peri-c
area

You refer the patient to a periodontist who agrees to see her later that day.

to peri-ca

time
30

cost
20

0
score

14

peri-ca
area

Two weeks later you receive a note from the periodontist. He examined the patient and determined she had a region of hypersensitive dentin which he treated with three separate applications of dicalcium phosphate and alteration of plaque control procedures.

He informed you that the patient is now comfortable and suggested that your office contact her to arrange a complete dental examination.

time

to peri-cb

cost

30

30

-2
score

14

peri-cb
area

Your office contacts Mrs. J. several days later to arrange a complete examination.

She states that she was disappointed that you could not treat her sensitivity and has decided to contact another dentist for a complete examination.

end of simulation

time
0

cost
0

Figures 8A, 8B, 8C.

Special sections are developed for complications, medications, or any unusual aspect of the simulation, following the same format. When the programmer and the designer review the cards, each can alert the author about any confusion, completeness, and presentation of the section. Completed cards are filed in the programmer's work box, programmed cards are filed in the "finished" work box, and questionable cards are placed back in the author's work box for his response. The cards serve as a checking system for the status of each simulation.

Results

The transition from cards to meaningful computer displays has proven very effective. The authors who were having difficulty encompassing all the possible choices available have found this to be a very productive method for completing simulations. The programmers use the cards as their programming "manuals" and if any card or section is unclear, it can easily be clarified by checking with the author. The evaluator can identify every choice for scoring and for recording decision pathways. The instructional designer can visualize structure and sequence, and the editing and debugging of the problem, once it is programmed, is done by editing cards or writing new cards for individual displays. This system has been used to develop twenty simulations to date and has allowed the Project to meet its schedule of national panel review for each group of simulations.

An author's manual based on the card system is in development. Authors are not expected to follow every statement specifically and make each simulation look identical. The guidelines allow the author to stay within the framework of the main model, thus conserving programming and editing time, while providing a degree of uniformity expected by the user. The manual contains detailed indexes of data, treatment, slides, radiographs, and additional instructions for summaries and library references.

Conclusion

Our experience to date using a coded card system for developing simulations indicates that this is a very useful and practical method for authoring. The system allows a viable team approach to the production of sound instructional materials. Undoubtedly, as we continue to develop simulations, refinements and additional specialized cards will evolve. Although this discussion is based on a dental model and specifically describes its application to the Plato system, the coded card method would seem to be readily adaptable to computer applications in other health fields.

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A Computer-Based Student Appraisal System: Automated from Sign-On to Item Analysis

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Background

Since 1971, the School of Basic Medical Sciences (SBMS) at Urbana-Champaign (UC) has been involved in the development and delivery of an innovative educational approach to the preclinical year(s) of medical education. When the School opened in the fall of 1971, basic science faculty and local practicing physicians prepared a basic medical sciences curriculum designed to provide medical students with the skills and knowledge necessary to allow entry into a clinical training program after 10 months of study. The present (1978) curriculum contains 13 basic medical science disciplines and is organized into a five-volume document. The curriculum includes over 400 self-instructional units and incorporates over 4,000 specific learning objectives. Each curriculum unit includes all necessary components (e.g., objectives, key words, self-tests, learning experiences) to allow the students to proceed at their own rate of progress and in a manner consistent with their own learning style (1).

In addition, to demonstrate the relevance of basic science to clinical medicine, each of the 400 learning units is related to one of nine clinical problems or diseases, e.g., Peptic Ulcer, Coronary Heart Disease. While studying the learning units, each student is provided multiple opportunities to interact with local practicing physicians and their patients. These interactions serve to facilitate the correlation of the basic science content with clinical problems or diseases. The specific patient problem is used as the entry point into interdisciplinary principles of basic science.

Student progress in the SBMS-UC program is assessed by three methods: (1) self-testing by the students via pre- and post-test questions (Levels I and II) in each learning unit, (2) objective, cognitive assessment with a comprehensive diagnostic examination (Level III) given after each of the curriculum divisions (clinical problems), and (3) an oral examination (Level IV), given by a physician, in which the student's ability to relate the basic sciences to each clinical problem is tested (2).

Level III Goals

A Level III examination is a cumulative examination covering all the basic science units included in a single clinical problem. Each of the nine Level III examinations includes approximately 180 questions and requires four to five hours to complete. Each Level III question is based on the instructional objectives which are included in each learning unit. The primary goal of the Level III student assessment procedure is to provide a meaningful learning experience for the student. Specifically, the objectives of the procedure include: (a) to improve student learning, not to assign grades; (b) to provide short-term goals toward which to work, by clarifying for students what learning outcomes are expected and by providing them with feedback concerning their progress; (c) to be diagnostic by revealing the learning strengths and weaknesses of individual students in each discipline learning unit; and (d) to provide immediate feedback, thus allowing students to assess their progress so that they can take immediate corrective action. This feedback is also given to the faculty advisors (3).

The Level III process complements the philosophy and flexibility of the SBMS-UC program. Students may choose to study the clinical problems in any order and may also determine their own pace and the amount of time between the examinations.

Computer-Assisted Rationale

A computer-assisted instructional (CAI) system was turned to as the medium on to which the Level III process could be implemented. This medium was especially attractive because it permitted achievement of the desired flexibility and previously mentioned objectives. The interactive nature of a CAI system facilitates the implementation of a "teaching examination." It also allows some form of tutoring feedback (dealing with specific questions during the examination) tailored to the responses made by the student. Further, examinations can be processed individually and scored automatically, with summarized information being printed out in a matter of minutes and available to both the student and his/her advisor. Consequently, a computer-assisted examination program named LEVEL3 was developed and implemented with the technical assistance of personnel from the School's Medical Computing Laboratory.

Systems Hardware and Software

LEVEL3 is written in TUTOR for PLATO IV as implemented on a CDC 7600 operated by the Computer-Based Education Research Laboratory on the Urbana campus. For student interaction, standard PLATO IV terminals are used. For additional administrative manipulation of the program and for hard copy output of student results, a PLATO IV terminal with an attached GE Terminet 1200 printer is used.

Student Use of System

Since students are proceeding through the curriculum at their own pace, they are naturally prepared to take each Level III examination at times that differ from those of their peers. The LEVEL3 program is designed for the independent administration of the examination to each student; the first step of the completely automated process is the scheduling of an examination.

Students begin by sitting at the PLATO IV terminal and calling up the "Level III Scheduler." The scheduler is displayed on the screen and provides the student with the following options:

1. A student may schedule a specific terminal on a specific date and time. If the terminal or the date and time have already been scheduled by another student, the requesting student will be told to make an alternate choice.

2. Students can schedule as many units (unit = one hour) as is felt necessary to complete the examination. Units may be spread over a period of 24 hours and need not be scheduled in one block of time.

3. Students may cancel pre-existing reservations and reschedule the examination.

Once the reservation is made, the student is assured of being able to take the examination at that time and on the terminal requested. On the day of the scheduled examination, the specified Level III is automatically activated for the student's use.

Administration of the Examination

When the student first signs into the LEVEL3 program (Figure 1), he/she is presented with an explanation of the use of the program (e.g., scoring, skipping questions, erasing an answer, etc.) and a list of the clinical problem examinations from which to choose (Figure 1,A). After an examination is chosen, a list of disciplines tested within it and number of questions per discipline is displayed on the PLATO IV screen. The student then selects the order in which the disciplines will be presented during the examination (Figure 1,B). This choice of a discipline branches the student to a block of examination questions which are presented linearly. As the student moves through the questions in each discipline, his/her answers are scored by the computer; no performance feedback is presented until the student has completed all questions in the discipline. The student, however, retains some control of the program in that he/she may omit the question and receive a zero score for the item or skip the question and return to it after having seen the remaining questions in that discipline (Figure 1,C and D). After completion of a discipline, i.e., all questions either answered or omitted, the student is then presented with his/her discipline score. At this point, the student may opt to review the questions answered incorrectly (recycle) or proceed to the next discipline.

Insert Figure 1 about here

During the recycling or review process, called the raised series, the student is given the opportunity to correct previous errors. The questions that were either omitted or answered incorrectly are displayed; the incorrect answer(s) is(are) also displayed. The student is asked to try to correct the prior error(s) and is given "bonus" points for each question answered correctly. These "bonus" points are added to the original score and a "raised score" is produced. If the student cannot supply the correct answer on the first recycle attempt, he/she is coached toward the correct answer by the computer program. At any time during the raised series, the student may request the correct answer (Figure 1,E). After the raised series is completed, the raised score for the discipline is calculated and presented; the student is allowed to progress to the next discipline of his/her choosing. When the student has completed all disciplines within the examination, he/she is presented with an on-line summary of scoring information, i.e., discipline scores, total test score and total test raised score. A hard copy printout of the examination results is available generally within one hour after the student signs-off the system (Figure 2).

Insert Figure 2 about here

Two types of data are presented to the student on the hard copy printout: (1) scoring information and (2) specific diagnostic information. The former is represented on the top portion of the printout in the form of achievement data by discipline--class mean and median score, the student's score and raised score and the number of students on which the class mean and median were computed. The mean and median are presented so the student has some basis against which to relate their scores to the general level of peer performance. In addition, students may also compare their total score to a statistically estimated passing standard for each examination. This passing standard was not determined by faculty, but rather through linear regression analysis in which Level III scores were the independent variables and performance on the end-of-year certifying examination was the dependent (criterion) variable.

The bottom portion of the printout, in contrast to the top portion, is designed to offer students specific diagnostic information; the purpose is to encourage students to use the examinations as teaching/learning tools. For each student, the questions that were answered incorrectly on the initial pass through each discipline are displayed; the incorrect answers are also noted. An asterisk (*) is attached to those questions that were answered correctly during the raised series. Further, for each question, the specific curriculum unit and textbook references with page citations are supplied. In addition to the diagnostic portion of the printout, the student has access, on a secure basis, to a paper copy of the examination. With the information displayed on the bottom segment of the printout, a paper copy of the examination and textbooks, the student should proceed to understand why the particular responses he/she supplied were not correct.

Types of Questions and Scoring

The LEVEL3 system is designed to handle a wide variety of objective-type questions, i.e., multiple choice, matching and true-false. Additionally, questions may be added, deleted or revised rather easily within the LEVEL3 system. The question response format differs from the "one best response per item." Students are instructed that more than one response per item may be correct. The LEVEL3 program accepts and scores both the single, as well as multiple, response item. Each examination question is scored on a semicontinuous scale which ranges from -1.0 to +1.0 (2). This scoring approach provides a correction for guessing and permits partial credit on items.

Although the scoring approach and multiple response item format are somewhat complex, it was found that students preferred the multiple response format and partial credit approach to the single response, dichotomously scored items. Students indicated that multiple response items allowed more accurate assessment of their knowledge. Further, it was noted that examination mean scores and estimates of reliability were higher when generated from multiple response, semicontinuously scored items rather than the single choice, dichotomously scored items (4).

Item Analysis

As with the scoring of student responses and production of descriptive examination data (e.g., examination mean total score, median score), the analysis of item data is automated fully. The item analysis procedures utilized presently represent a significant departure from the procedures used in previous years. The major concerns that led to the new system focused on whether the theoretical appropriateness and empirical accuracy of the previous procedures could be improved and on whether the results could be returned to faculty in a more timely fashion. In previous years, data were often pooled for analysis across more than one clinical problem (Level III examination). For example, Anatomy items from Diabetes were analyzed with Anatomy items from Neurologic Disease. However, in the newly designed system, responses to questions are analyzed only in relation to the Level III examination and clinical problem for which they were written. Several advantages result from this alteration in procedure: (a) the test results are more satisfactory estimates of the students' knowledge relative to the information presented in a given clinical problem; (b) the item data (such as item mean scores) provide more accurate reflections of item characteristics; (c) the test characteristics (such as mean scores and reliability) are more accurate estimates of how the test actually functions; and (d) because items are analyzed only in relation to a specific Level III exam, item analysis results could be returned to faculty shortly after students complete an examination (5,6).

Relative to this fourth point, it is also possible to return item analysis data to faculty before all students have completed a particular Level III examination. It was found that relatively stable estimates of item characteristics can be produced from the examination performance of approximately 40-50 students, about one-half of the total number of students enrolled in the basic science program. In previous years, the item analysis was performed only after all students had completed the examination. Because of the self-paced nature of the basic science program, there is, at times during the program, a three-month interval between the time the first and last student complete an examination. Since item analysis data are provided to the basic medical science faculty for their use in modifying curriculum content and objectives, lectures and other learning experiences, timely return of the data is extremely important.

In addition to changes in the analytic procedures, other alterations were made. For example, data is collected and analyzed on one medium; in the past, data were passed from medium to medium (e.g, PLATO data file → ASCI tape → IBM tape → punched cards). Further, the new procedure is fully automated and requires no human intervention to hard copy item analysis data from various computer printouts to item analysis cards. Because the item analysis package was designed and implemented internally, it is no longer necessary to negotiate with outside service agencies to modify pre-existing packages (designed to accommodate one correct response per question) to handle multiple correct responses per item. In the past, several different computer packages had to be used to produce the needed test and item results. With the newly designed and implemented system, all analyses are done on PLATO (the medium on which the data are collected) by a single program. These several changes result in a substantial savings in computing time, personnel involvement and money.

A new format for the presentation of item analysis results has also been developed. The presentation of examination results contains data not available in the past; in particular, a graph with item mean scores and quintiles based on total subscores has been included to allow visual inspection of the discriminating characteristics of any given item. The reliability of the subtest has also been included, along with additional data about the subtest, such as its mean and standard deviation (the items of each specific discipline constitute a subtest). The correlations of item scores with subtest scores are also presented.

Insert Figures 3 and 4 about here

Study of Computer-Based Level III Examination Usage

A controlled study was conducted to determine if performance benefits accrued to students who were administered computerized Level III examinations when their performance was compared to that of students who were administered a paper copy of the examinations. Students were divided into two well-matched groups on the basis of prematriculation variables, such as undergraduate grade-point average and Medical College Admission Test (MCAT) scores. Yet, under two methods of administering Level III examinations, paper vs computer, a significant difference between the two groups on Level III performance emerged over time (7).

The students who used the computer-assisted method, in which an interactive review of questions answered incorrectly is emphasized, earned higher Level III scores on examinations that occurred later in the year. Since the content of the examinations interrelates through the inherent overlap in the content of clinical problems, the higher level of performance of the students in the computer-assisted group was attributed to the cumulative effect of the review offered during the interactive review of errors on the examinations. Additional support for this argument comes from analysis of performance of the two groups on a college constructed certifying examination and on the National Boards Part I examination.

When the amount of time spent in interactive review by students in the computer-assisted group was analyzed in relation to performance on the National Boards and college certifying examinations, significant positive correlations were obtained. Based on these results, it was suggested that there is a clear learning advantage that occurs as students spend more time in interactive computer-assisted review.

In summary, data concerning performance at the level of discipline and overall scores on the year-end examinations and overall scores on the Level III examinations support the hypothesis of a learning benefit of the computer-assisted student assessment system. The evidence shows that the advantages were not due solely to the computer-assisted medium, but to the process made possible by the medium: a "teaching exam" with interactive review and immediate feedback (7).

Final Exam Review Series

As a means of reviewing concepts for preparation for the final examination, the Level III program also allows for students to repeat Level III examinations already completed. This option (REVIEW series) follows the RAISE series in form, providing feedback for wrong or partially correct responses and allowing students to call for the answer via a key function. Students may choose to review items in two ways; 1) they proceed in a similar fashion to a Level III test, reviewing as many disciplines in the examination as they wish; or (2) students can concentrate on a single discipline over several examinations, thus integrating concepts within the subject matter. Formal records are not kept during this series. However, anecdotal information suggests that students benefit from such an option, particularly when studying for their end-of-year comprehensive examination.

Student Reactions

Merits of the Level III system are documented through student responses made in end-of-year questionnaires. When asked if Level III tests should be administered to the entire class at a prespecified time, 71% of the class disagreed. Most of the students desired the examination administration flexibility that currently exists. Students also showed a strong preference to the automated system over similar paper and pencil examinations. Almost the entire class (95%) responded unfavorably to an administration of the Level III tests on paper, due to the differential time in making results available to them. These data indicate a preference for an automated testing system tailored to individual student needs.

Conclusion

A detailed description of a comprehensive computer-based student appraisal system (Level III) has been presented. The entire system, which has been implemented on PLATO IV, is fully automated from the scheduling and delivery of basic medical science examinations to the analysis of student performance data. Further, all item analyses are done within the program and are output to hard copy via a Terminet printer. The computer-based appraisal system was designed to provide frequent, meaningful, diagnostic feedback to students relative to their progress in the basic medical science program.

The Level III system has been operational since 1971 and has undergone considerable revision to improve its efficiency and effectiveness. The system and its revisions have been received rather well by faculty and students. It has been found that users of the automated appraisal system perform better than nonusers on end-of-year certifying examinations. It is believed that their performance benefits were associated with the interactive review in which students engage during the computer-assisted examinations.

In conclusion, the Level III PLATO IV testing system is both an effective and efficient mechanism for the appraisal of student performance and for the timely production of item analysis data--both of which are important components in curriculum review and revision.

Note of Appreciation

The authors would like to express their appreciation to OCE staff member Karen Gaddis for her efforts in the operation and maintenance of the Level III system.

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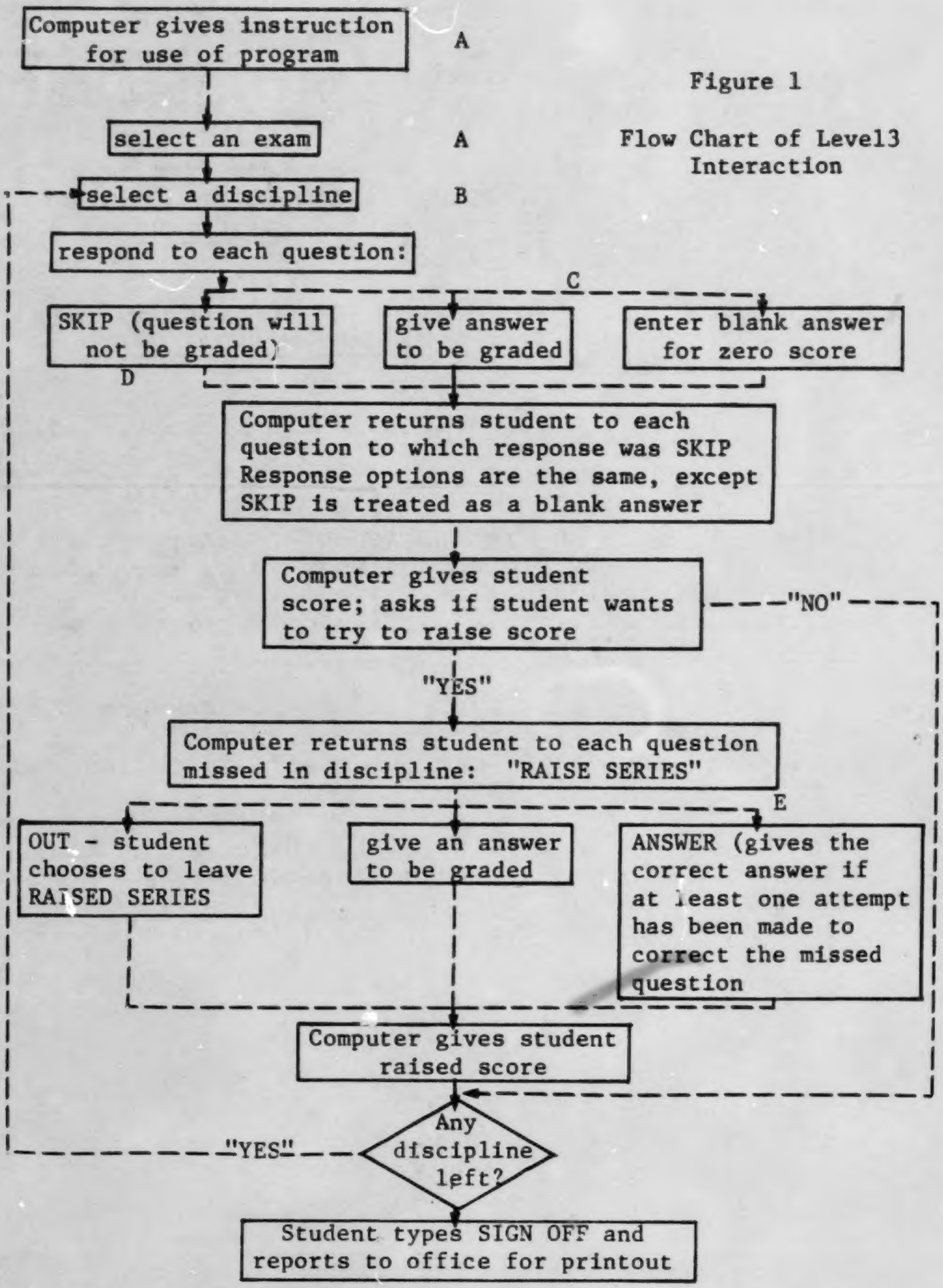

Computer gives instruction for use of program
A
select an exam
A
select a discipline
B
respond to each question:
C
SKIP (question will not be graded)
D
give answer to be graded
enter blank answer for zero score
Computer returns student to each question to which response was SKIP Response options are the same, except SKIP is treated as a blank answer
Computer gives student score; asks if student wants to try to raise score
"NO"
"YES"
Computer returns student to each question missed in discipline: "RAISE SERIES"
E
OUT - student chooses to leave RAISED SERIES
give an answer to be graded
ANSWER (gives the correct answer if at least one attempt has been made to correct the missed question
Computer gives student raised score
"YES"
Any discipline left?
Student types SIGN OFF and reports to office for printout

Figure 1

Flow Chart of Level3 Interaction

Student Name:
Date of Examination: 10/02/78
Date of Printout : 10/02/78
N = 18

Figure 2
Inflammation Examination

Discipline	# of Quest.	Mean	Score	Raise Score
Anatomy	31	51.2	75.5	87.0
Behavior sci.	16	41.6	51.0	66.0
Biochemistry	10	53.2	51.6	52.0
Embryology	10	57.0	71.6	86.0
Genetics	10	51.2	63.3	88.0
Histology	18	61.6	67.1	77.0
Microbiology	17	47.5	46.5	60.0
Neuroscience	10	43.3	65.0	65.0
Pathology	22	55.2	43.0	58.0
Physiology	15	40.0	33.3	47.0
Statistics	6	72.7	86.1	86.1
OVERALL	165	51.3	58.4	70.1

A total score of 38 or below is flagged with a question mark (?).

If you consistently earn total scores of 38 or below, it is possible that you may not pass the Basic Science Comprehensive.

Listing of questions missed on FIRST SERIES (FS)
("*" next to the question number indicates correction in RAISE SERIES)

Discipline		Unt-Qst.	FS answers(s) given	Reference
3*	anatomy	1-7	1 4	Wd. 15-16;Hh. 16;Sn. 8
6	anatomy	3-4	1 2 3 4 5	Sn.526-30;Wd.584;Hh.416-[illegible]
7*	anatomy	3-6	2 3 4	Sn.530;Wd.586;Hh.419
9*	anatomy	3-11	1 2 4	Hh.383,386;Sn.502;Wd554
10	anatomy	4-2	1	Sn.517;Wd.549;Hh.407-9
13	anatomy	4-8	4	Sn.507-10;Wd.525;Hh.390
14	anatomy	4-12	4	Sn.512,517;Hh.409;Wd.53[illegible]
19*	anatomy	6-7	4	Sn.606;Wd.591;Hh.459-60
20	anatomy	6-8	1	Sn.574;Wd.587-9;Hh.459,61
22*	anatomy	7-2	2 5	Sn548;Wd.557;Hh.442,443
24	anatomy	7-8	1 2	S493,545;Wd.522-3,526;H350
27*	anatomy	9-4 -- 9-7	2 4	Sn.556,Wd.572;Hh.448,449
31	anatomy	9-12	2	Hh.476;Sn.569;Wd.582
32*	behavior sci.	1-1	4	Cockerham, p.9
35	behavior sci.	3-5	2	Holler & DeLong p.77
37	behavior sci.	3-7	1 2	Holler & Delong p.82
40	behavior sci.	4-3	4	Mayerson, p.88
41*	behavior sci.	4-4	3	Mayerson, p.21
43	behavior sci.	13-1	1 2 3 5	Cockerham, pp. 66-67
44	behavior sci.	13-6	1 3	Mayerson, p.127-8
45	behavior sci.	13-7		Bernstein et al, p.19
46*	behavior sci.	13-8		Mayerson, p.141
47	behavior sci.	13-9	3	Cockerham, 0.84
49	biochemistry	2-3		Lehninger II, p.25
51	biochemistry	2-11	4	Lehninger, p.374-75
55	biochemistry	3-7		White(5th ed.),141-42
56	biochemistry	3-10	3	Lehninger, 50
60	embryology	1-4	1	Moore, p.13
67*	embryology	2-4	3	Moore, pp.22-23
6[illegible]*	genetics	1-2	3	Sutton 141-46;Obj.B-1

0388

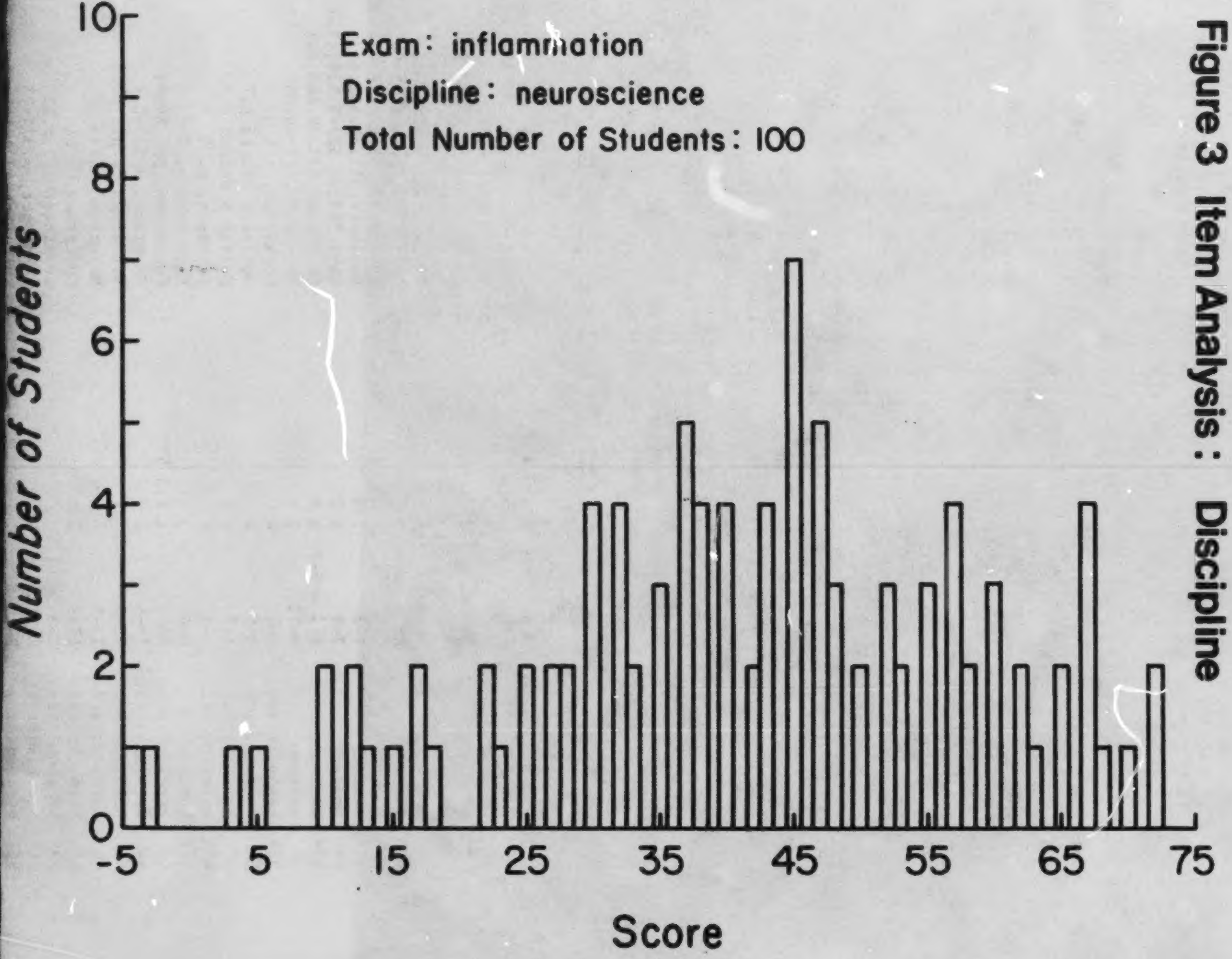

Figure 3 Item Analysis: Discipline

Figure 4: Inflammation Examination

1978-79, Anatomy Q. 23

7-7 Which of the following veins is/are venae comitantes?

1. anterior tibial
2. posterior tibial
3. peroneal
4. femoral

Correct answer(s): 1 2 3
Reference: S548,555;W570;H361,447,458

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            **** I T E M   A N A L Y S I S ****

ITEM MEAN                                 *
+1 +
   .
   .
   .
   .                             *
   +
   .
   .
   .
   .                    *
 0 +           *
   .
   .
   .
   .
   +
   .  *
   .
   .
   .
-1 +--1--------2--------3--------4--------5---QUINTILE

           Response Choices
          -----------------------------------
           1*      2*      3*       4       5
          -----------------------------------
prop      0.54    0.55    0.38    0.27    0.17
R(pb)     0.20    0.17    0.17   -0.30   -0.04

Item Mean Score:                  0.27
Item Standard Deviation:          0.57
Item-Subtest Correlation:         0.29
Number of Students:           99
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CMI DENTAL ANATOMY

Gary L. Jones, D.D.S. and Dianna Newman, Ph.D.

Clinical dentistry by its very nature is taught through individualized self-paced teaching methods with every student having his own unique dental experience. This method is used out of necessity as students treat human subjects and human subjects have individual dental needs. Dental faculties accept individualized self-paced teaching method in clinical dentistry with its multitude of complexities. These include the necessity of monitoring each student's progress toward expected goals in a number of clinical areas. Inherent in this process is a large number of instructor hours.

Review of Literature

Historically, didactic dental education has been taught by traditional methods. All students progress together with the same exposures, lectures, laboratory experiences, and the same dentaform teeth, produced from the same molds, produced under strict quality control.

In the past few years some instructors, departments, and Colleges of Dentistry have individualized self-paced didactic dental education. A prime example of this is the College of Dentistry, University of Florida[1] which has individualized its entire program. These attempts have raised the questions of student evaluation procedures, which methods produce the best dental student, and which requires the most staff time and cost differences.

Most research in individualized dental education has shown little or no difference in student performance. Some authors have reported that students taught by individualized self-paced methods achieved more than those taught by traditional methods[2-9] while others have found the opposite. Most authors report that individualized self-paced teaching methods require less student time[10-11] for equal mastery level. Many report a more favorable student attitude toward the individualized self-paced teaching methods.[12-13]

This paper deals with a method whereby the computer manages the instruction (CMI) of each individual student through a segment of a course in Dental Anatomy and Occlusion. The computer package was designed to relieve the instructors of the major menial tasks required of an individualized self-paced course. The CMI package presents test items to the student, grades each individual question, reports feedback to the student after each question, selects the next learning experience based on the student's performance, and maintains the course grade book where each student can view his own performance at any time. The CMI teaching method frees the instructor of his repetitive non-instruction duties allowing him to directly assist students in learning.

METHODOLOGY

Sample

The population consisted of sixty-six freshman students enrolled in a required dental anatomy class at a midwest dental college. Stratified random sampling was used to select twenty-two students as the experimental group. Stratification was based on two subscores of the Dental Aptitude Test and sex of subject. Subjects were assigned a rating (1=high, 2=low) on their accumulated science and visual perception DAT subscores and divided into four groups based on their combined rankings. Since research has indicated that females may perform differently than males in individualized instruction at the college level,[14-15] sex of subject was also used in selection of the sample. The remaining forty-four students served as the control group, also referred to as the lecture-only group.

Procedure

Students in the control group received in-class presentations handouts and textbook references. They were also expected to attend class lectures. Two in-class mimeographed multiple choice tests were administered. The items for this test were randomly selected for the experimental groups pool items. As in most traditional classes, students were not allowed to repeat the test. Mastery was set at 70 percent.

Students in the experimental or independent study group were given the option of attending class presentations and were allowed to self-select their study resources. Among their options were slide tape presentations, handouts, textbook references, class lectures and library materials. This group was also given a sign-on to the PLATO-CMI(1) terminal for individualized testing of each objective through computerized multiple choice questions.

The PLATO-CMI system was designed such that each unit, or module, covered three sub-units of material. Each sub-unit contained one objective, learning resources which would aid the student in mastering that objective, and a pool of 25-30 test items (multiple choice questions) over that objective. The first two units or modules were used for this experiment and consisted of information on dental terminology and morphology of incisors.

The students in the experimental group were required to master each objective in sequential order before progressing to the next module. Mastery of the objective required completion of five out of six items (83% correct). Each attempt at mastery received a unique sample of six items randomly selected by the PLATO-CMI system. Non-mastery automatically locked the student out of testing for a 24-hour period, suggesting he review learning resources for the area of incorrect response. After this time delay, the student could re-enter the testing phase for that objective and attempt to show mastery again.

Dependent Variables

All sixty-six students were given a pre-test before assignment to experimental and control groups. This test consisted of 36 multiple choice items, six for each objective covered. These items were randomly selected from the PLATO-CMI pool of items developed by the instructor. The same instrument was given as a post-test to all students at the end of the lecture sequence for the two modules. Students in the experimental group were also asked to complete an attitudinal evaluation of the PLATO-CMI system and resources.

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(1) Control Data Corp., Minneapolis, Minn.

RESULTS AND DISCUSSION

Pre and Post-Test Scores

The statistical design for pre and post-test scores was a two-factor 2x2 analysis of variance with repeated measures on the second factor. The first factor was learning environment (lecture, independent study); the second factor was time (pre-experimentation, post-experimentation). Table 1 presents the means and standard deviations of the subjects' test scores for pre and post-experimentation. Table 2 summarizes the analysis of variance of the test scores.

A test of interaction between learning method and pre - post scores was not significant ($F=2.06$, $p > .05$). An examination of the means shows an almost parallel increase from pre to post scores for both the independent study and the lecture only groups. This trend is supported by a significant difference between pre and post scores ($F=351.14$ $p < .01$) but no significant difference between study methods ($F=0.78$ $p > .05$).

These results would indicate that those students in the independent study-CMI section were able to keep up with and perform equally with those in the traditional classroom. This further supplements theoretical research indicating that the more important use of computer monitored instruction is not in improved learning but in matching students' learning styles.

Attitude and Efficiency

In addition to examination of student gain in knowledge, the researchers were also interested in attitude and instructional efficiency. Those students in the experimental group were asked to rate the effectiveness of various components of the independent study options. Seventy-three percent recommended the program to other students; 68 percent recommended that the computerized testing sequence be continued as either a learning aid or a review aid while 73 percent recommended continuance as a testing device.

When asked to rate the overall instructional aspect of the program (1 was high, 5 low) the average rating was 1.72 while the overall testing rating was 2.05. The comments for the testing aspect indicate that this lower score was due to students desire for more questions per unit.

Time

The mean or average time consumed by the CMI student was eight minutes on the first try and one minute on successive tries per module or unit. Students taking the traditional written test took a minimum of 20 minutes to answer an 18 item test with some students taking the full 55 minute period. There are three possible reasons why traditional students took from three to seven times longer to take the test than the CMI students.

One reason is that traditional students have only one chance on each test and hence take longer with each question than the CMI students who can retake the test as many times as required without penalty. A second reason may be that the CMI students receive immediate feedback after each item. This feedback may allow students to clarify areas thus making quicker responses on preceding questions. The mimeographed test used in the traditional classroom does not allow feedback on each item which may be tutorial to other items. A third possible set of reasons the CMI student requires less time in test taking is cognitive preparation, test anxiety, and general attitude of the student.

Instructor Time

In terms of instructional efficiency classroom time was saved by the use of CMI. One class period per month was used in the traditional classroom for student evaluation or about nine hours of classroom time per academic year. CMI allows students to take their test on their own free time freeing nine hours of the instructor's time for additional lectures or helping individual students.

The CMI method takes a large amount of instructor time for original preparation but saves time by eliminating non-instructional functions for the instructor. PLATO-CMI grades, records and maintains the student records. The system allows the students to see their "grade book" whenever they want on the terminal. It helps answer students' questions regarding correct answers by giving immediate feedback on each item.

Although PLATO-CMI in dental anatomy was developed for only two units the first year, it appears the added instructor time required to develop the CMI materials may be equalized after two years thus netting a time saving from that point on. This allows instructors to direct their time toward development of better instruction and more personalized student learning.

Further Information

After the first two units were tested all students were allowed to use PLATO-CMI. Six months later all sixty-six students were asked the question -- "which method of testing would you prefer and why?" Of the 15 students (23%) who preferred mimeographed tests half (11.5%) preferred the structure of being forced to keep up and one-fourth (6%) felt they developed a better understanding of the subject matter under conventional testing. One felt it was a game and another student thought it was too easy.

Of the students who preferred PLATO, most responded they favored having the freedom to take a test when they desired, and the ability to retake the test items missed.

All but one student felt the immediate feedback to test items helped their understanding and reinforced correct response. Traditional tests in this area are usually returned approximately two class periods later with only incorrect responses noted. The one student felt that professional students did not need reinforcement.

The students were also asked to evaluate the learning resources displayed on the terminal. Fifty-two percent of the students felt they were helpful, twenty-four percent felt them a waste of time and twenty-four percent did not use the learning resources.

CONCLUSIONS

As for student performance, there appears to be no advantage or disadvantage to either traditional testing methods or CMI testing methods. However PLATO-CMI did show a considerable savings of time for the student (minimum of one-third the time), the classroom (one hour per month), and for the instructor (no grading and recording of grades). Attitudinally students preferred

CMI three to one over traditional methods. Most students felt the immediate feedback they received after each test item was the strongest educational tool for the CMI method.

Table One

Means and Standard Deviations for Test Score

	Pre-Test		Post-Test	
	Mean	St. Dev.	Mean	St. Dev.
Individual Study	12.5	3.2	20.23	3.6
Lecture	12.25	2.8	21.39	1.8

Table Two

Analysis of Variance for Test Score

Source	M.S.	df	F
Group	6.06	1/64	0.78
Time	2478.67	1/64	351.14**
Group XTime	14.56	1/64	2.06
Group Error	7.75		
Time Error	7.06		

**p < .01

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Title: A Study To Compare The Effectiveness of Two
C.A.I. Formats And The Subsequent Correlation
Of Individual Learning Style to Performance

Author: James Magero

This study investigated two different computer assisted instructional design formats, and the effect that individual learning style had on performance. Outlined below is a review of the procedures, findings, conclusions and recommendations for future research in these areas pertinent to computer assisted instruction.

Review of the Study

In 1976, eight programmed instruction lesson had been designed to teach students physical diagnosis interviewing skills at the Rockford School of Medicine, University of Illinois. One year later it was decided to rewrite these lessons for use on the teaching computer (PLATO) and to choose one representative lesson in which to study in a formal, indepth manner.

The lessons used the "Feinz" format which was an open-ended approach consisting of students ranking appropriate responses to the problem, deciding whether the response was appropriate or inappropriate and then receiving the feedback from the computer as to their accuracy and an explanation as to why their response was accurate or inaccurate.

Most of the clinical medical programming used a different approach known as the "Hippocrates" method which was less open-ended in that students were not forced to rank responses, decide on appropriateness or give any explanation as to why a response was accurate or inaccurate, but were simply branched through a program and at the completion of the lesson were given numerical score.

Since there has been a continuing controversy over the best methods used to teach physical diagnosis and since computer assisted instruction appeared to be a viable alternative method it was decided to compare these two I.D. formats and measure the learning effectiveness.[1] Individual learning style has recently been found to have a

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1. Hoeffer, Barnett, Op. Cit. PP. 52-61

significant effect on performance so it was also decided to include learning style as a component when comparing the instructional design.[2]

To test these concepts a representative lesson dealing with heart disease was programmed into PLATO in both the Feinz and Hippocrates format. In addition a learning style inventory designed by Smilansky and Foley was used to determine the students' individual learning preference.

An experimental design was devised and eight research hypotheses were formulated. Four groups of students were randomly drawn from the University of Illinois Medical Center, Chicago Campus and Rockford Campus. These two campuses were used so that a large enough population could be available from which to draw a representative sample and because the educational programs at the two campuses differ with respect to the setting and the educational emphasis. The Rockford Campus consisted of a smaller student body located in a middle size town and place the instructional emphasis on primary care dealing to a high degree without-patients.

The Chicago Campus consisted of a large student body, located in a major metropolitan area and placed the instructional emphasis on specialty education dealing to a high degree with in-patients.

It was felt that the large sample and the segmentation of the groups would provide more accurate and meaningful results for the study. Each student was asked to complete a learning style inventory and one of the formats of a computer lesson that dealt with physical diagnosis. The following hypotheses were developed and examined:

1. There is no significant difference between the Rockford Feinz group and the Rockford Hippocrates group.

2. There is no significant difference between the

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[2] Dunn, Dunn, Price, Op. Cit. PP. 418-420

2. Chicago Feinz group and the Chicago Hippocrates group.

3. There is no significant difference between the Chicago Feinz group and the Rockford Feinz group.

4. There is no significant difference between the Chicago Hippocrates group and the Rockford Hippocrates group.

5. There is no significant difference between the Chicago Feinz group and the Rockford Hippocrates group.

6. There is no significant difference between the Rockford Feinz group and the Chicago Hippocrates group.

7. There is no significant difference between the Rockford and Chicago students in their ability to perform in the post-test.

8. There is no significant difference between a particular learning style and a particular group.

The results of the first seven hypotheses were subjected to statistical analysis using the Analysis of Variance Technique. This particular technique was used to determine difference in performance between the groups being analyzed.

The results of the eighth hypothesis were subjected to statistical analysis using the Spearman Correlational Coefficient. This technique was used to determine any correlation between performance and learning style among the groups being analyzed. An alpha level of .05 was established as the point at which the results were said to have significance and the null hypotheses could be rejected. The findings of this analysis are reviewed below.

Summary of Findings

The first seven hypotheses which compared all of the possible combinations of groups in terms of performance showed no significant difference. Therefore, the null hypotheses were retained.

The eighth hypothesis which dealt with the effect learning style would have on performance did reveal some significant differences. The categories of learning style (Abstract/Concrete, Teacher oriented/Student oriented, Passive learner/Active learner, Group study/Individual study) were correlated with various groups (Feinz group, Hippocrates group, Chicago group, Rockford group, Chicago Feinz group, Chicago Hippocrates group, Rockford Feinz group, Rockford Hippocrates group). Although, most correlations did not demonstrate significance, the student oriented learner and the active learner who used the Feinz format did correlate significantly with performance. The active learners who were Chicago students also correlated significantly with performance. And the individual study learners who were from Rockford and used the Feinz format correlated significantly with performance.

Conclusion

The study showed that when the two formats of computer-assisted instruction are compared, there is no difference in student achievement as a whole. Therefore, at first glance, one would conclude that no matter what method is used, student learning will be comparable. By further analyzing the student performance, in regards to learning style, a different conclusion could result. Since active learners scored higher on the Feinz format than did passive learners, and since there was not a similar correlation on the Hippocrates format, one could conclude that there is a significant difference between the two formats as it relates to the active learner.

Since student oriented learner scored higher on the Feinz format than did teacher oriented learners, and again there was not a similar correlation with the Hippocrates format, one could conclude that there is a significant difference between the two formats as it relates to the student oriented learner.

Since the individual study oriented students who were from the Rockford and used the Feinz format correlated significantly with performance and the group oriented students did not, again one could conclude that the Feinz format would be more beneficial for this group of students than the Hippocrates format.

Two major conclusions can be derived from this study:

1. That the open-ended approach and the more closed approach to presenting information has no significant effect on the learning of the individual involved when analyzed as a whole.
2. A pattern can be established that relates particular learning style to performance on computer-assisted instruction.

The fact that there was no performance difference when the two formats were analyzed as a whole, but the differences did surface when learning style were isolated could be attributed to several factors:

1. One of the reasons for this result could be that the open-ended (Feinz) approach better lends itself to the computer medium for active learners.
2. Another factor could be that the open-ended (Feinz) approach in any format better lends itself to the active learner.
3. Another factor could be that the small sample size did not allow for large enough groups to be analyzed according to learning style.

Recommendation for Application

Since learning style has emerged to be an important factor in comparing two instructional design formats several applications for educational technologists, health science faculty and computer experts became apparent. They are:

(1) That learning style must be considered when selecting instructional strategies and developing materials for delivering educational content.

(2) That, although, a group such as medical students might be considered homogeneous because of the type of requirements and screening procedures

that are utilized to select a particular type of student, this homogeneity does not necessarily extend to the individual learning style. And instruction must therefore, be modified to accommodate the individual learning style if quality education is to be provided.

(3) The computer assisted instruction modality has been further supported by the study due to the interactive nature of the medium. Therefore, professionals involved at all levels of the educational process should further explore the potential of computer use in their respective educational setting.

(4) When identifying the target audience for a portion of instruction, the group should be carefully stratified by learning style.

(5) When developing educational materials or methods of instruction, it is possible that the instructor would have to utilized several modalities to deliver the same instructional content to a student and audience comprised of different learning style preference.

Recommendation for Further Research

The research presented in this paper has merely skimmed the surface of a potentially dynamic approach to instruction. In order to further document the findings presented here and expand on those findings the following research activities would be helpful.

(1) Conduct similar studies in other areas of education using a large population based in order to better document the findings.

(2) Research that has been completed in the past which compared different methods of instruction should be undertaken again, but the population should be segmented by learning style.

(3) Devise a unit of instruction and modify the presentation of the unit to accommodate individual learning styles and document the effectiveness.

(4) Design an entire course designed toward satisfying

(4) the individual learning styles of the students. Compare those results to the traditional class presentation.

(5) Perform follow-up analyses on performance to check for retention or attitudinal shifts.

Researchers in all phases of education should attempt to segment their groups by learning styles before conducting an experiment since totally different results can be obtained from different learning style groups.

PHYSEU - A System of Learning Medical Physiology. J.A. Lipsky, J.C. Curry, M.N. Nishikawara, H.P. Pieper, J.A. Rall, L.L. Gabel. Department of Physiology, The Ohio State University, Columbus, Ohio 43210.

Intended Audience: Health Sciences Interest Group.

Since 1970, the College of Medicine has operated two tracks for medical students progressing toward the MD degree - the Independent Study Program and the Lecture/Discussion Program. In the latter program, the basic sciences of Anatomy, Physiology, and Physiological Chemistry are presented in the first 22 weeks of the curriculum. Anatomy is presented by lectures and laboratories; Physiological Chemistry utilizes a modified Keller plan; Physiology depends upon the traditional lecture format. One problem with this traditional method is that the student behaves passively; he comes to grips with Physiology only before examinations. In many cases, it is only then that he realizes his deficiencies. The PHYSEU program was developed in order to activate the students early and to spread their study efforts more evenly over the 22 week period, and thus enhance learning.

PHYSEU consists basically of 15 computer self-evaluation units. Each unit has two sections, A and B. Each section contains 25 multiple choice questions. Units become available to students after specific concepts have been presented. Students must perform at or above the 80% level in each unit in order to progress to succeeding units. Failure to achieve this level of performance in section A necessitates additional work on the student's part prior to attempting section B. Performance below 80% in both A and B results in a required conference with a tutor or professor before the next unit is made available to the student. In this manner, areas of weakness are resolved early, either by the student himself or in consultation with members of the staff. Our experience indicates that a large number of students resolve misunderstandings by self-study. Computer scoring and record keeping are maintained only for self-evaluation and informational purposes.

At the present time, PHYSEU provides approximately 1000 questions covering the entire range of basic physiological concepts normally provided to medical students. Each question has 5 possible responses. The student must make a decision for the record. His decision, right or wrong, results in immediate feedback of information. His first decision is used for determination of performance level. However, he is usually given one or two more opportunities to arrive at the correct response to a question. In the process, the student is presented with additional feedback. The entire program contains approximately 5000 immediate feedback responses. It is required that all units be completed within the 22 week period. The large majority of students quickly learn to plan their activities so that units are completed before traditional written exams which cover the concepts emphasized in PHYSEU.

PHYSEU has been accepted by the medical students as an excellent adjunct to learning. More than 90% of the students (1976 & 1977, n = 311) responding at the end of the 22 week period rated the program as Excellent or Good. The results of in-house examinations (4) averaged approximately 80%. Scores of the Physiology section of a shelf copy of the National Board Examination were significantly better than those of previous classes. Finally, comments from users at other institutions indicate that PHYSEU is readily adaptable to various educational formats.

MedPLATO
Sharing Computer-based Medical Education

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An overview of the MedPLATO Network is presented along with an analysis of student use of instructional materials. The paper primarily addresses those involved with computer-based instruction in the health sciences, presupposing familiarity with the PLATO system. The second section will be of most interest to readers familiar with the MedPLATO Catalog(1).

The MedPLATO Network

MedPLATO is a network of health science institutions sharing a common computer system and software management system. It is a user subset of the larger University of Illinois PLATO system, comprising approximately 10% of the user population. The Network served over 1,200 students during the 1977-78 academic year, with approximately 40,000 hours of total use. Based on our current use of 1,500 hours per week, projected use for 1978-79 will be 80,000 hours. The majority of terminals is located at the geographical branches of the University of Illinois College of Medicine. Other sites include a number of hospitals and schools within Illinois, and in Tennessee, Oklahoma, Maryland, Connecticut, and New York. Many other locations use our catalog on an informal (and unrecorded) basis.

Student, faculty, and author use of MedPLATO are tied together by a software management system, including the MedPLATO Catalog, self-assessment testing, data-collection and reporting, and health science group communication facilities. Utilities also provide automatic lesson and test generation. Long before student lesson-related comments were a PLATO system provided feature, our project automatically collected student comments on all lessons in our on-line catalog, and forwarded them to the lesson author. We now are experimenting with providing our students with personal note capability.

Until this Fall all student and multiple signons were routed directly to the MedPLATO Catalog where they

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* Thanks to Michelle Arnopol, who tabulated the data.

were provided access to all completed lessons authored at the MedPLATO sites. This year we have encouraged each site to provide a set of locally selected lessons to their students using 'mrouter', along with access to the comprehensive catalog. We have also encouraged the elimination of multiple signons for student use. These changes, which have been adopted by all schools, have the objective of promoting a closer integration of PLATO with local curricula, without losing student access to the comprehensive library of lesson material. PLATO is not required for most students on the Network, but is available as a library-like resource, permitting student access to a larger variety of material than would be the case if lesson availability were dependent on formal institutional approval at many different schools.

Student use of instructional material is recorded with a comprehensive management information system which was originally created by Mr. Vincent Wu and has recently been revised by Mr. Frank Mabry. Figure 1 illustrates use patterns for the Network from 1975 through October of 1978. "Total Use" includes all time logged on MedPLATO site terminals. "Instructional Use" includes material accessed by student or multiple signons through the MedPLATO Catalog. It does not include most allied health science lessons, which were indexed and accessed separately.

In practice, many students obtain author signons during the course of their four years of medical school and subsequently use that signon for instructional as well as authoring purposes(2). Consequently, the difference between instructional and total use is attributable to both authoring and instructional use by author signons. Starting with the fall of 1978, an improved datakeeping system is allowing us to distinguish author editing time from instructional time, and to record use of lessons even when they are not accessed via the MedPLATO Catalog.

The MedPLATO system is used by students in four modes: instructional (lessons), testing, communication, and recreation. Approximately half of PLATO use at the School of Basic Medical Sciences (SBMS) at Urbana is from our student self-assessment system(3). The Urbana School is the only current heavy user of computer-based testing within the Network.

Personal and group communications constitutes over one third of student use of PLATO throughout the

Network, and over 1/2 of total use. These communication options are used for administrative, service, instructional, and recreational purposes. It is a unique and fascinating use of PLATO within the educational environment that has yet to be understood. A few schools in the Network have given students access to recreational games on PLATO in the evenings since January, 1978. We have yet to consider the impact of recreational use on promoting or discouraging instructional use.

Approximately one third of the over 350 lessons currently available on the MedPLATO catalog were developed between 1973 and 1977 at SBMS Urbana under a four year contract from the Bureau of Health Manpower. (4) In most cases, these basic science lessons were generated by the Medical Author group, which was separate from the regular SBMS Urbana faculty.

During this period the Medical Author Group explored the idea of networking, by placing terminals in locations outside of the University of Illinois. Although outside use of existing materials expanded quickly, little lesson development was undertaken by remote users. In 1976 the College of Medicine's Center for Educational Development in Chicago began contributing lesson material in the clinical sciences, and a small number of outside lessons were submitted.

When the Medical Author Group project dissolved in the spring of 1977 leaving only a service staff, a substantive question arose concerning the continued growth and expansion of available lesson material. This matter has not yet been resolved in terms of formal faculty participation in PLATO authorship. Continued growth of the Network is indicated, however, by the fact that 90% of the approximately 50 lessons added to the MedPLATO catalog during the 1977-78 academic year originated from remote sites.

Analysis of Student Use

We have not previously taken a comprehensive look at medical student use of lessons. MedPLATO authors have developed many theories concerning the style of lessons students want and use, the subject areas they are most interested in, when, how and why lessons become obsolescent, and what kind of development group is needed to produce high quality lessons. By describing student selection of lessons, we hope to discover any large differences in group characteristics that may exist, and thus offer some evidence to the debate.

Our analysis addresses student use of our library of instructional materials collected in the MedPLATO Catalog. It excludes indexes to non-medical materials and communication options other than those which take the form of an essay or PLATO lesson. Our data collection system was unable to trace through other indexes, rendering the small but relevant set of lessons accessed by this means (i.e. veterinary medicine, chemistry) inaccessable. Group and personal notes are by nature different from instructional lessons, and we already know that they have high usage.

The data collection system provided us with total usage and total entry figures for each lesson on a monthly basis. These figures were accumulated for the period from August 1, 1977 through June 1, 1978; for the most part encompassing the 1977-78 academic year. The PLATO Statistical Editor written by J. Michael Felty (statedit) was used to store the data and run descriptive statistics. Al Avner's Statistical Package (stat) was used for group comparisons.

Of the over 350 lessons currently available on the MedPLATO catalog, 315 lessons were available for part or all of the 1977-78 academic year, and were utilized in the analysis. Very few of these lessons have the capability of registering student completion, and few collected student scores. Thus, the "usefullness" of groupings of lessons was examined based only on number of entries and minutes of use. The total number of entries and total minutes of use for each lesson in the set had the high correlation coefficient of .89. The scatter plot in Figure 2 shows the distribution of lessons according to entries and use. The average lesson has a mean use of 11.6 minutes per entry, with an average number of 176 entries per year.

The average lesson was most likely used for a longer period of time by serious users. The mean includes browser entries and cannot be used to indicate how long most students used the lessons. A group of 58 lessons, each having over 4000 minutes of use for the year, was selected to represent a high use set (top 20th percentile). This group included both lessons available throughout the year and those lessons available for only part of the year which met the criterion. The group of lessons had a mean usage per entry of 15.4 minutes with an average number of 430 entries per lesson for the year. It is further characterized in Table 1.

Information associated with each lesson in the MedPLATO catalog was used to group lessons for the analyses of four independent variables; date of publication on the Catalog, topic covered, origin of the material, and style of presentation. By looking at the lessons across these general lines, we hoped to identify trends in student selection and use within the catalog.

Twenty eight lessons were available for only part of 1978. A preliminary analysis of monthly totals indicates that both curricular demands and the novelty of new lessons lead to differential use. Therefore, it appeared to be unwise to attempt a projection of yearly usage for lessons that were on the catalog for only part of the year. A few of these lessons, however, appear in the top 20th percentile of catalog lessons. Consequently it appeared to be equally unwise to completely exclude them from the analysis. Our compromise was to include lessons available for less than the full year if it increased the mean for a particular group.

The catalog itself was instituted in 1974, so all lessons completed before that time were included in the 1974 group. Other lessons were grouped according to the year in which they were submitted to the catalog. With the exception of those translated from the Kansas University Pharmacology Consortium, most lessons have been periodically modified in response to user comments.

A number of possible assumptions relating publication date to usefulness have been considered by the Network authoring community. One is that lessons are becoming obsolete because they are not updated extensively and frequently enough. Another is that through user feedback, lessons are improving with age just like wine. A third is that authoring skill and understanding of PLATO is leading to a general improvement in the quality of materials produced. Table 2 provides data relevant to these hypotheses.

With the exception of 1976, there appears to be a surprisingly uniform contribution of high usage lessons. While 28% of lessons submitted during 1976 were highly used, all other years indicate between 20% and 22% contributions. The figures for 1975 were calculated both with and without the 50 lessons translated from the Kansas University Pharmacology Consortium. This set, unique because it was translated from another system, had unusually low usage. Its large number of lessons dominated the group mean. Thus, the figure excluding the translated lessons is more representative of materials authored on the Network.

An initial look at source, topic, and style differences does not indicate a large group effect that could account for the contribution from 1976. This was the last year of the Medical Author Group project, and the contributions of a large group of experienced authors could be responsible for the effect. A larger set of materials were contributed during that year, perhaps indicating a greater emphasis on lesson production that resulted in higher quality.

Table 3 includes analysis of variance results with lessons grouped by year of publication, and mean minutes of usage per lesson as the dependent variable. The analysis reveals distinct group effects, but they account for only a small portion of the variance. Table 4 indicates a similar but smaller group effect for date when mean number of lesson entries is the dependent variable.

Given that each year's contribution to highly used lessons is fairly stable, it appears to be the case that the lessons are not quickly deteriorating in their usefulness, either because they are updated by the authors or because they contained basic information that is not subject to fast decay. (We will ignore the unpleasant possibility that students are avidly devouring obsolete instruction.)

A common assumption concerning student interest in topics is that clinical lesson material is of greatest interest to all medical students. We also operate under the assumption that students will select lesson material generated by their own instructors or recommended by their instructors or education coordinators.

The group comparisons in Table 3 reveal that topic had the largest group effect, and thus best predicted which lessons would be highly utilized. Topic group membership accounted for 26.6% of the sample variance in comparisons of mean use for each group. Mean entry comparisons (Table 4) indicated slightly lower but still large and dominant effects. There are also large differences in the percentage of lessons from each topic group reaching the top 20th percentile of lessons (Table 5). A further comparison of the highly selected lessons for basic science students indicated an almost exclusive basic science orientation, while clinical groups tended to select half basic science and half clinical lessons.

Biochemistry and physiology are considered to be the toughest disciplines by basic science students. Their concerns are reflected in high usage and selection of these materials. A look at the self assessment exams in the high usage set indicated particular interest in biochemistry and cardiology. In addition, biochemistry and physiology were highly selected topics for both clinical and basic science students.

Table 4 indicates that the physiology lessons had the highest selection mean for any group in the analysis. The physiology lessons in the top 20th percentile reflect a number of different sources and authors, and contain a majority of tutorial lessons. Although it is a highly volatile instructional discipline, students are utilizing all materials that are available and would be likely to appreciate additional lessons in this area.

The highly selected biochemistry lessons were produced by the same author with one of two collaborators, even though over 1/3 of the topic set was comprised of lessons created by other authors. Mean entries for biochemistry are average, indicating that each lesson tends to be used for a longer period of time at one sitting. Some quality selection appears to be involved in the high usage of biochemistry lessons as well as general interest.

Many of the microbiology lessons were authored by the same person, and the set contains a long series of lessons on parasitology, not a topic of overwhelming interest to medical schools in the United States. Both the mean entries and mean use figures for microbiology are low, lending support to the conclusion that lack of interest is the major factor in their low usage.

The pharmacology lessons also have low usage; however, the mean entries are average in contrast to microbiology, indicating that the lessons are selected but are little used. Total use for the set is also disproportionately low, discounting the hypothesis that interest may have been spread out over the large number of lessons available. These lessons are currently being evaluated by pharmacology faculty at all branches of the U of I College of Medicine. Their evaluation may help determine the cause of the low use.

Most of the high usage of anatomy lessons comes from basic science students. This is an area where there is little controversy in curriculum objectives and subject matter. The anatomy lessons selected contain both tutorial and drill lessons, apparently highly useful as a whole to basic science students. Regular faculty were involved in creating many of the lessons in this set, also increasing the liklihood that they would be used.

A basic science faculty member either authored or selected the small number of genetics lessons. These lessons are integrated into the curriculum at Urbana, thus promoting high usage at one school. A number of the lessons are laboratory simulations, also increasing the likelihood of high use.

Expository lesson is a catch-all classification for demonstration lessons and essays on topics which involve little or no interaction. It is not suprising that they have reasonably low usage. The self-assessment category includes short exams over the full range of disciplines and health assessment lessons. The reasonably high selection of these materials confirms the popular theory that students want to use PLATO for self-assessment.

As would be predicted, the clinical materials are highly selected, having high mean usage, entries, and representation in the set of highly used lessons. Basic Science students do use clinical lessons, but appear to be more task-oriented than expected in that they concentrate on those basic science lessons immediately applicable to their studies. Thus, while there is usage of clinical materials, no clinical lessons appear in the most highly selected set of lessons from basic science student groups.

Many authors predict that students prefer drill and simulation styles to tutorials, holding that medical students want to use PLATO for practice, and that these modes are more practice than instructionally oriented. Another assertion is that PLATO is ideally suited for simulation and drill lessons because of its graphics power, and ability to interact with the student. It can thus compete favorably with other instructional mediums in these areas.

As Table 6 indicates, approximately the same percentage of available tutorial lessons (18%) appear in the highly selected lessons as do drills (17%). High quality tutorial lessons do appear to have an important function for students. We frankly expected drill lessons to make a better showing then they did.

Apparently medical students, bright as they are, still need an occasional "tutor" along with practice.

Laboratory and clinical simulations by far account for both the highest mean entries and highest mean use, with 33% of the group reaching the top 1/5 of lessons. This interest confirms the belief that PLATO will be of most interest to students in areas where other instructional media cannot compete.

All large sites were included in Table 7. It should be noted that both Peoria and Rockford's small contribution has been increased through the submission of lesson series to the catalog. Both series are receiving high usage this year. Table 3 and 4 indicate that source has the second highest group impact of those examined on selection and use of lessons throughout the Network. Sources vary tremendously in size and resources available for development. It would be unwise to make any qualitative judgements concerning either the sites or the participating authors based on these figures. Tennessee lessons are all biochemistry and involve the same two faculty members, one having initially generated many of the lessons while a member of the Medical Author Group at Urbana. Their figures, therefore, reflect more on the people involved than the environment present at the site. The high percent for Peoria also reflects the contribution of two people who are highly successful authors.

On the other hand, the impressive contribution from Chicago involves a large group of authors and a variety of styles. The predominance of clinical materials produced there can explain some of the success. But the site also has the resources to provide experienced educational and programming support to faculty developing lesson material. This continuity and experience apparently pays off.

The materials developed at Urbana with faculty participation and under contract to the Bureau of Health Manpower make a respectable showing of 29% and 23% becoming highly used. Those materials generated by faculty appear to be most useful, constituting only 10 % of the catalog, but contributing 29% to the high usage set of lessons. The other remote sites are contributing their fair share of useful lessons, indicating that the mysteries of PLATO can be mastered at a distance.

Some of the selection differences between basic science and clinical students have been mentioned throughout this analysis. Highly used lessons from each site were compared to the Network-wide set in order determine the representativeness of the list. We also were interested in examining the importance of local authoring on student selection.

On the whole, basic science students selected the same sets of lessons, primarily anatomy and biochemistry. However, Urbana students also selected locally authored genetics lessons, while Chicago students selected a set of self assessment materials which were also authored locally. Tennessee students followed this pattern, even more heavily emphasizing the biochemistry materials authored by their faculty.

Clinical students demonstrated a broader range of interests, generally selecting as many basic science lessons as clinical lessons. These groups did not show the same local orientation that was present for basic science students, perhaps indicating a less narrowly defined set of learning goals, or a wider range of applicable materials. Their continued use of basic science materials does indicate that PLATO can be useful to review previously learned material that is being used in a new context.

Conclusions

It is apparent that a fairly large and stable set of lesson material exists which is highly useful throughout the Network. Lessons generated at one location can be useful at another, even though lessons authored by local faculty will tend to have higher local usage. An element of quality also appears to distinguish many of the highly used lessons, irrespective of style, source, or date of publication.

A large demand for materials in physiology and biochemistry is evident. Traditional forms of instruction may not be dealing adequately with these disciplines, leading students to seek whatever help they can receive on PLATO. The MedPLATO community of authors and students appears to have many common goals that are promoted through this cooperative venture.

We will be proceeding in an examination of more specific variables that may lead to high lesson use, such as complexity and length of the program, use of gaming techniques, the inclusion of graphics, as well as identifying talented authors.

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3. Sorlie, W. E. and Jones, L.A., "Description of a Computer-Assisted Testing System in an Independent Study Program, Journal of Medical Education, Vol. 50, January 1975, 81-83

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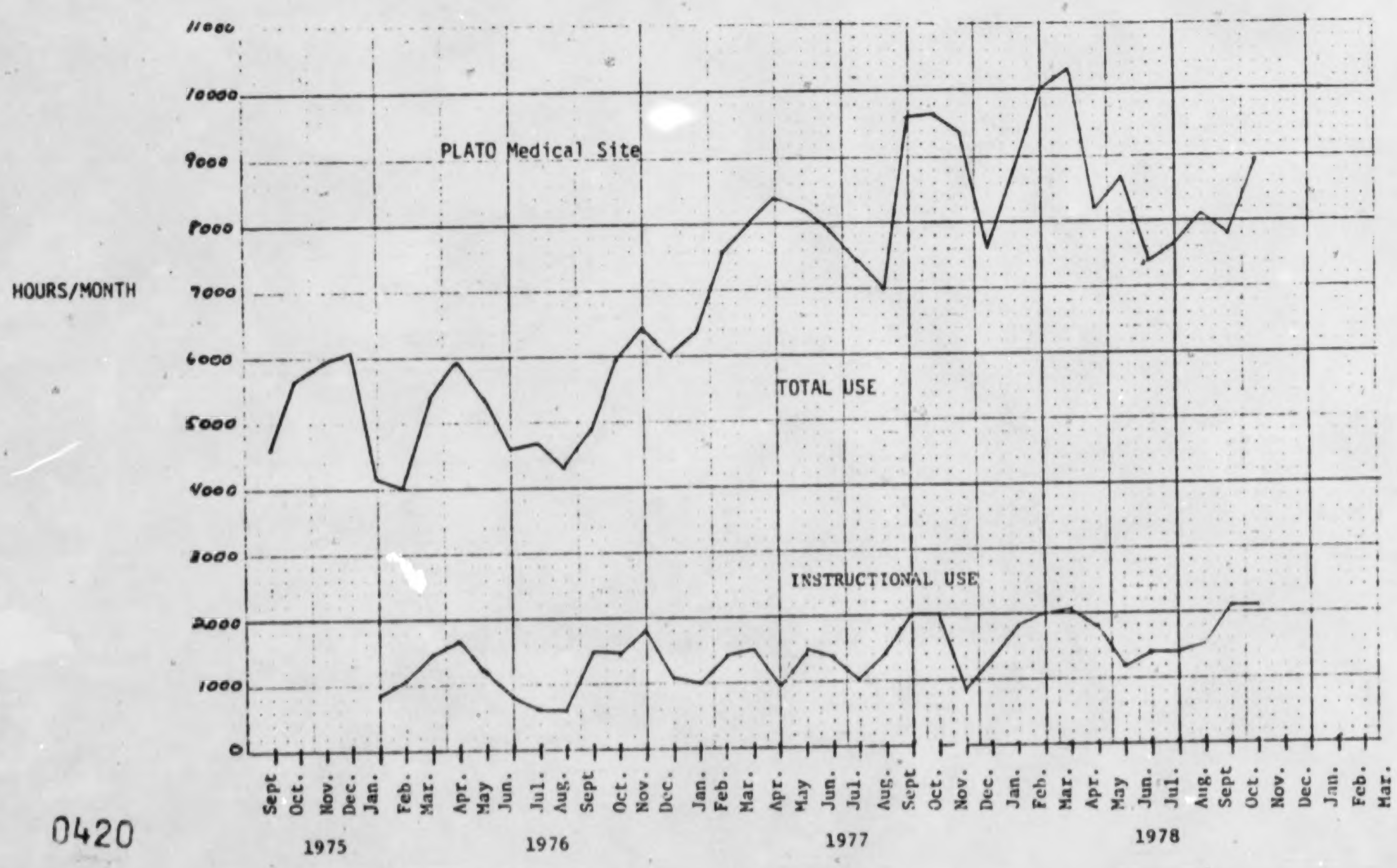
Figure 1


PLATO Medical Site
HOURS/MONTH
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
TOTAL USE
INSTRUCTIONAL USE
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Nov.
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Figure 2

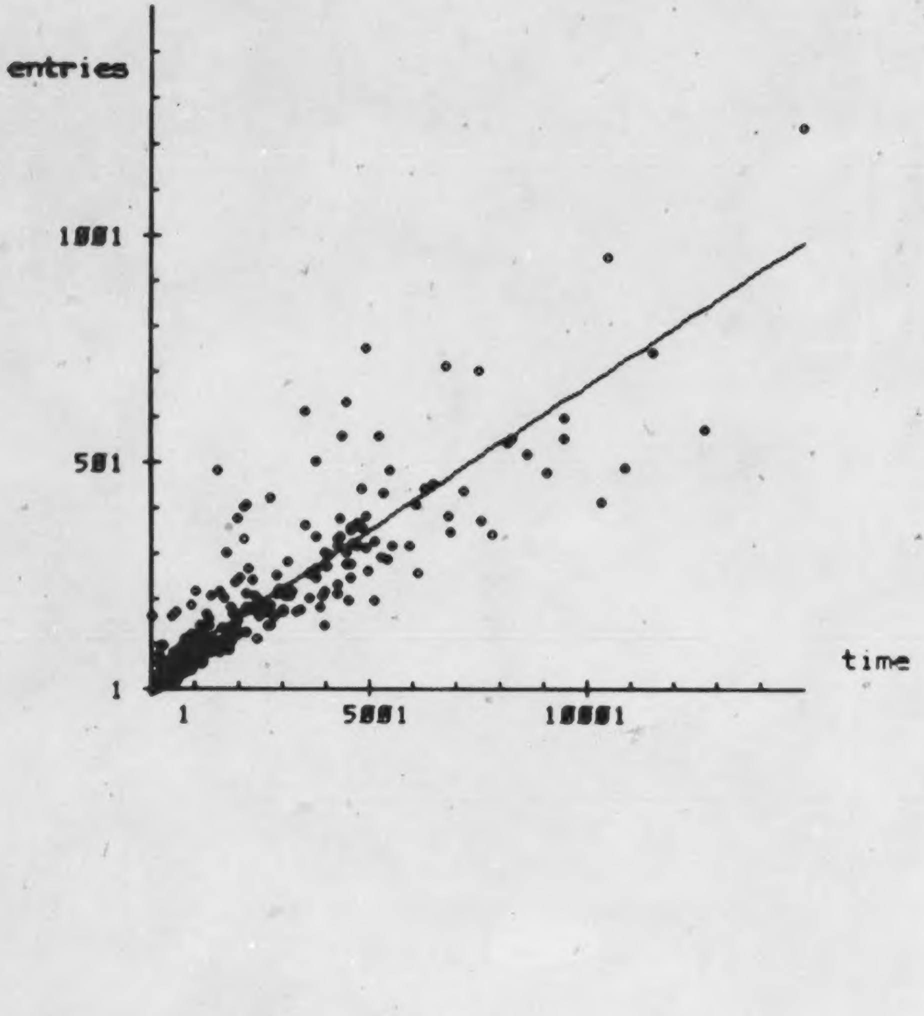

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Table 1

Top 20th Percentile
Mean Minutes of Use Per Lesson

	N	Mean Minutes of Use	SD
Date			
1974	4	6363	2787
1975	15	6809	2622
1976	26	6334	2615
1977	11	5251	1322
1978 wpy*	1	9458	0
Topic			
Physiology	8	5448	1515
Microbiology	2	5228	960
Biochemistry	11	7183	2672
Pharmacology	0	0	0
Anatomy	13	5914	1445
Pathology	1	4543	0
Genetics	3	4872	750
General	2	4564	460
Self-assessment	5	5637	2704
Clinical	13	7487	3433
Source			
BHM	20	6412	2263
Urbana	9	5655	1609
Chicago	17	7073	3180
Oklahoma	2	4837	579
Tennessee	11	7182	2672
Maryland	2	4567	437
Peoria	2	5055	182
Rockford	0	0	0
Other	7	5667	2349
Style			
Tutorial	26	6587	1306
Drill	8	8060	3441
Simulation	23	9242	3146
Expository	1	0	0

*wpy=including part-year data

Table 2

Date of Inclusion on the MedPLATO Catalog Related to 1977-78 Lesson Status (N=311 because of missing data)

Date of cataloging	Contribution to 77-78 cat	Contribution to top use set	% of group in top use set
1974	6%	7%	21%
1975	35%	26%	13%
1975wkp*	24%	26%	20%
1976	30%	45%	28%
1977	17%	19%	22%
1978fy**	2%	0%	20%
1978py***	10%	0%	0%

*wkp=excluding Kansas pharmacology lessons
**fy= Lessons on the catalog for the full year
***py= Lessons on the catalog for only part of the year

Table 3

Group Comparison Data
Mean Minutes of Use Per Lesson

	Mean	SD	p	Sample Variation Accounted for by Group Membership
Date			p=.0002	6.8%
1974	2941	2386	F(4,306)=5.576	
1975	1737	2342		
1976	2731	2823		
1977	2124	1983		
1978 wpy*	699	1731		
Topic			p<.00005	26.6%
Physiology	4421	2004	F(9,256)=10.283	
Microbiology	1043	1385		
Biochemistry	3254	3078		
Pharmacology	661	611		
Anatomy	3535	2369		
Pathology	1870	1614		
Genetics	2454	2088		
General	1445	1554		
Self-assessment	2957	2258		
Clinical	3575	2668		
Source			p<.00005	13.9%
BHM	2436	2575	F(6,283)=7.629	
Urbana	2626	2489		
Chicago	3606	3108		
Oklahoma	1604	1634		
Tennessee	4094	3746		
Maryland	2030	1454		
Peoria	4125	1083		
Rockford	3881	0 (excluded from the analysis)		
Other	1124	1118		
Style			p=.0010	5.8%
Tutorial	1966	1996	F(3,272)=5.561	
Drill	2016	2629		
Simulation	3105	3155		
Expository	863	1461		

*wpy= including part-year data

Table 4

Group Comparison Data
Mean Number of Entries Per Lesson

	Mean	SD	p	Sample Variation Accounted for by Group Membership
Date			p=.0014	5.5%
1974	257	209	F(3,275)=5.302	
1975	131	141		
1976	213	205		
1977	177	165		
1978 wpy*	62	104		
Topic			p<.00005	17.8%
Physiology	316	107	F(9,197)=4.754	
Microbiology	74	84		
Biochemistry	195	140		
Pharmacology	181	267		
Anatomy	279	174		
Pathology	126	106		
Genetics	180	95		
General	166	197		
Self-assessment	240	201		
Clinical	294	245		
Source			p<.00005	11.9%
BHM	163	148	F(7,321)=6.167	
Urbana	171	148		
Chicago	270	234		
Oklahoma	119	103		
Tennessee	234	134		
Maryland	126	92		
Peoria	323	166		
Rockford	135	106		
Other	113	153		
Style			p=.0024	5.2%
Tutorial	149	133	F(3,268)=4.915	
Drill	160	155		
Simulation	243	232		
Exposition	181	267		

*wpy= including part-year data

Table 5

Lessón Selection by Topics

Topic	Total min. for group	Contribution to 77-78 cat	Contribution to top use set	% of group in top use set
Physiology	56,100	5%	14%	66%
Microbiology	34,419	12%	3%	6%
Biochemistry	120,574	14%	19%	30%
Pharmacology	42,965	24%	0%	0%
Anatomy	111,622	13%	22%	42%
Pathology	18,700	3%	2%	11%
Genetics	20,799	3%	5%	38%
General	21,580	5%	3%	14%
Self-assess.	62,625	7%	9%	28%
Clinical	157,412	15%	22%	33%

Table 6

Lesson Selection by Styles

Topic	Contribution to 77-78 cat	Contribution to top use set	% of group in top use set
Tutorial	52%	45%	18%
Drill	17%	14%	17%
Simulation	22%	40%	33%
General	2%	1%	9%

Table 7

Lesson Selection by Sources

N=283, excluding part year data
Dual Sources Involved

School	Total min. for group	Contribution to 77-78 cat	Contribution to top use set	% of group in top use set
DHM	214,368	31%	34%	23%
Urbana	71,176	10%	16%	29%
Chicago	197,379	29%	29%	36%
Okla.	22,456	5%	3%	15%
Tenn.	110,538	10%	19%	41%
Md.	36,456	6%	3%	15%
Peoria	20,640	1%	3%	50%
Rockfd.	4,012	0%	0%	0%
Other	91,044	27%	12%	9%

COMPUTERIZED TEST PRODUCTION IN THE MEDICAL FIELD

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Introduction

The development of optical scanners capable of sensing and scoring mark sensed test answer sheets was the first step in computerizing educational testing. The second step involved using a computer system for storage and retrieval of test items from a test item bank during the production of examination papers. The third step provided a basis for integrating the capabilities of the optical scanner and the item retrieval system with the content to be examined. The basis for this integration is a computer-based Competency Analysis Profile (CAP).

The purpose of this paper is to describe a computer-based test production model which integrates all of these capabilities - Competency Analysis Profiling, test item banking and retrieval, and optical scanning currently in use in the medical and allied health fields.

Definition of Content - Competency Analysis Profiling

The Competency Analysis Profile component of the model primarily serves the purpose of defining and documenting the competencies that are to be tested. It is beyond the scope of this paper to describe the process for determining and validating the competencies that should be included in the profile.

The CAP profile is essentially a two-dimensional matrix. Rows of the matrix are designated by letters of the alphabet while columns are designated by numbers. Each row in the profile is referred to as a competency category and contained within that row is a series of competencies that constitute that category. A portion of a CAP profile is presented in Figure 1.

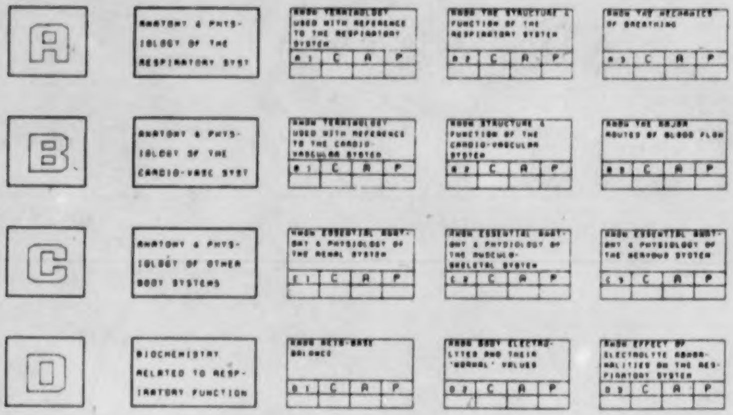
A
ANATOMY & PHYSIOLOGY OF THE RESPIRATORY SYST
KNOW TERMINOLOGY USED WITH REFERENCE TO THE RESPIRATORY SYSTEM
A 1 C A P
KNOW THE STRUCTURE & FUNCTION OF THE RESPIRATORY SYSTEM
A 2 C A P
KNOW THE MECHANICS OF BREATHING
A 3 C A P
B
ANATOMY & PHYSIOLOGY OF THE CARDIO-VASC SYST
KNOW TERMINOLOGY USED WITH REFERENCE TO THE CARDIO-VASCULAR SYSTEM
B 1 C A P
KNOW STRUCTURE & FUNCTION OF THE CARDIO-VASCULAR SYSTEM
B 2 C A P
KNOW THE MAJOR ROUTES OF BLOOD FLOW
B 3 C A P
C
ANATOMY & PHYSIOLOGY OF OTHER BODY SYSTEMS
KNOW ESSENTIAL ANATOMY & PHYSIOLOGY OF THE RENAL SYSTEM
C 1 C A P
KNOW ESSENTIAL ANATOMY & PHYSIOLOGY OF THE MUSCULO-SKELETAL SYSTEM
C 2 C A P
KNOW ESSENTIAL ANATOMY & PHYSIOLOGY OF THE NERVOUS SYSTEM
C 3 C A P
D
BIOCHEMISTRY RELATED TO RESPIRATORY FUNCTION
KNOW ACID-BASE BALANCE
D 1 C A P
KNOW BODY ELECTROLYTES AND THEIR 'NORMAL' VALUES
D 2 C A P
KNOW EFFECT OF ELECTROLYTE ABNORMALITIES ON THE RESPIRATORY SYSTEM
D 3 C A P

Figure 1: Competency Analysis Profile

For example, competency category (row) C might be designated "Anatomy and Physiology of Body Systems" while one competency (designated C 1) within this competency category might be "Know Anatomy and Physiology of the Renal System". Other competencies within this competency category would be designated C 2, C 3, and so on.

Once the competency categories and competencies have been identified, they are entered interactively into a file in the computer. A program reads this file and plots a CAP chart on a plotter in the format described above and in the format illustrated in Figure 1.

Item and Parameter Files

Items for the test item bank are developed to test specific competencies in the CAP profile. Two additional computer files constitute this component of the model. One file contains the test items. Items are entered via computer terminal according to a prescribed format. Figure 2 shows the item format.

```
34004          1  ITEM ID. 34004
34004.01       0  Pes cavus may be associated with
34004.02          all of the following conditions,
34004.03          EXCEPT:
34004.04       0  1.  Myelodysplasia.
34004.05       0  2.  Friedreich's ataxia.
34004.06       0 *3.  Talocalcaneal synostosis.
34004.07       OE 4.  Peroneal muscular atrophy.
34193          1  ITEM ID. 34193
34193.01       0  In fully developed fat embolism
34193.02          syndrome, death is most likely to
34193.03          result from;
34193.04       0  1.  Central nervous system damage by
34193.05              fat emboli.
34193.06       0  2.  Massive hemorrhage into alveolar
34193.07              walls.
34193.08       0  3.  Right heart failure.
34193.09       0  4.  Renal cortical failure.
34193.1        OE*5.  Respiratory function failure.
```

Figure 2: Item Format for Entering Questions into File

The other file contains item parameters which provide the user with meaningful information about the item. One essential parameter that is always contained in the parameter file is the designation of the competency in the CAP profile that the item is designed to test. Other parameters which establish question type, taxonomic level, source of item, etc. may also be stored in the parameter file.

Another essential feature of the parameter file is that it has provision for accumulating and storing item analysis data for an item. Each time that the item is used in an examination, the item analysis is appended to the parameter file.

Production of an Examination Paper

The production of examination papers is generally undertaken by a committee. Committee members begin with the CAP profile, deciding how much emphasis (how many test items) each competency category, and in turn each competency in the profile should receive.

Each committee member then receives a dump or printout of every item in the bank sorted by competency category and in turn by competency. The dump also contains all item parameter information including item analysis information.

```
ITEM ID. 34004

Pes cavus may be associated with all of the following
conditions, EXCEPT:

1.  Myelodysplasia.
2.  Friedreich's ataxia.
3.  Talocalcaneal synostosis.
4.  Peroneal muscular atrophy.

    Competency Category          -     E
    Competency                   -     E 10
    Question Type                -     A 4
    Taxonomic Level              -     Factual
    Core Level                   -     Important
    Correct Response             -     3
    No. of Times this Item
      Has Been Used              -     2

This item was used in 1978 Paper 1, Question 9.  Item
Difficulty = 86, Pt. Bis. = 16, Rel. Index = 6.

            No. of     Proportion of Group Selecting
          Candidates       Options 1   2   3   4   5
Total         79                   5   5  86   4   0
Top 3rd       27                   0   7  89   4   0
Mid 3rd       25                   4   4  88   4   0
Low 3rd       27                  11   4  81   4   0

Test Score Means (Total = 323)   198 228 221 197   0

This item was used in 1976 Paper 2, Question 104.  Item
Difficulty = 89, Pt. Bis. = 38, Rel. Index = 12.

            No. of     Proportion of Group Selecting
          Candidates       Options 1   2   3   4   5
Total         90                   0   3   1  89   7
Top 3rd       20                   0   0   0  99   0
Mid 3rd       30                   0   3   0  90   7
Low 3rd       30                   0   7   3  77  13

Test Score Means (Total = 313)     0 182 151 206 171
```

Figure 3: Dump of Item

The committee systematically reviews the items in each category, identifying the item numbers of the items they want on the examination paper.

A draft of the resulting examination paper is produced by entering the item numbers of the desired items into the computer. The desired items are selected from the file containing the test items and printed on a high speed printer. While the high speed printer is capable of printing multiple copies of the examination paper, it is often more economical to produce multiple copies by offset press.

An alternative approach to test production is for the test committee to describe the characteristics of the examination using the parameters which categorize the items. The computer then searches the bank and indicates whether the user's specifications can be met. If all specifications are met, the user can then ask for a copy to be printed. If the specifications can not be met, then the user has to relax the criteria for selection of items. This approach to test production has not been used extensively by the test committees.

Test Analysis and Reporting

Once the examination has been administered, it is optically scored and the parameter bank is updated with the appropriate item statistics. Various reports are produced. A report to each examinee which indicates the examinee's performance in each of the competency categories provides the examinee with a diagnosis of his strengths and weaknesses. This is illustrated in Figure 4.

Paper 1 Student ID.:

Your Total Score is: 93 out of 129 or 72%

Breakdown by Category:

Category	Group Average	No. Right	No. Possible	%
A	60	17	23	74
B	64	4	7	57
C	50	2	4	50
D	57	2	6	33
E	65	7	11	64
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Figure 4: Examinee Performance by Competency Category

Another report which goes out to program directors indicates the performance of the examinees in that training program compared to the performance of the examinees in all the training programs. This report is provided by competency category as well and it is therefore possible for program directors to assess the strengths and weaknesses of their training program.

Conclusions

The system describes a model for managing an item bank, constructing a printed copy of the examination, scoring and analyzing tests, and providing reports. The system provides error-free examinations at a favorable cost, supplies information about the test and the examinees, and above all improves the quality of the item bank by storing each item's performance for every time that the item is used.

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Application and Testing of Computer Aided Instruction in Pharmacology

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Computer aided instruction has been in existence for more than a decade and a half (Brudner 1968). However, it has been only within the last five years that computer aided instruction has been developed and used with greater frequency in health sciences education (Fitzgerald 1973; Kamp 1975; LeFever 1976; Bitzer and Bitzer 1977).

Because this is still a relatively new teaching technique in the health sciences, very few controlled studies utilizing computer aided instruction in actual class usage situations exist. Thus, evidence about the effectiveness of computer aided instruction in comparison to other teaching methods is lacking (Vinsonhaler and Bass 1972).

A brief review of the literature on the use of computer aided instruction in the health sciences shows that research efforts fall into three main categories: (i) technical development of computer assisted case history exercises (Harless et al. 1973; Hoffer 1973; Warner 1974); (ii) evaluation of subject performance in completing computer case history exercises (DeDombal et al. 1971; Hillman 1971; Friedman 1973); and (iii) evaluation of the effect of computer aided exercises upon the subjects' learning and clinical performance (Fitzgerald 1973; Bitzer and Bitzer 1977). A search of the literature revealed no evaluative studies of the use of computer aided instruction in the subject area of pharmacology.

Computerized learning aides have been developed and used by the Department of Pharmacology at the University of California, San Francisco for the last five years.

The users have always rated these exercises highly and have consistently asked for more programs to be developed (Burkhalter 1976). However, it has not been objectively determined whether or not computer exercises affect student learning and/or attitudes.

With these facts in mind, it was decided to attempt to determine whether or not computer-aided instruction could affect student attitudes when used in conjunction with traditional modalities of pharmacology instruction (i.e., lectures and laboratories).

In order to satisfy this objective, a series of computer aided instructional programs was designed, developed and integrated into an established pharmacology course for third-year pharmacy students at the University of California, San Francisco. A questionnaire was used to evaluate the effect of these computer aided instructional programs.

MATERIALS AND METHODS

Subjects. The subjects were third-year pharmacy students at the University of California, San Francisco, who were enrolled in Pharmacology 136, central nervous system drugs, during the fall quarter 1976.

The students were asked on the first day of class to participate in a research project that would require filling out a questionnaire. They were told that participation would be completely voluntary and would not be associated with any incentives and that lack of participation would not result in any punitive measures. In addition, the subjects were informed that another questionnaire would be administered later in the quarter and that their responses to the questions on the questionnaires would be used to assess and influence the teaching strategies of the course in the future. The precise involvement of this project with computer-aided instruction was not mentioned, however, in order to preserve the blind characteristic of the experimental design.

Additional steps were taken to fulfill the obligations of ethical research and to adquately protect the subjects' rights. These included obtaining approval for this project from: the Dean and Executive Committee of the School of Pharmacy, the chairman of the Department of Pharmacology, the instructor in charge of the course, and the Human Experimentation Committee of the University of California, San Francisco.

Computer Aided Instructional Programs. Computer aided instructional programs were chosen for evaluation partly because students who had used computer-aided instruction at the University of California, San Francisco campus have indicated in the past that they liked it and would like to see more programs developed.

In addition, computer-aided instructional programs utilizing a case history type of format allow students to attempt role-playing and decision making processes in a situation simulating actual clinical practice and are a potentially valuable teaching format for use in pharmacology courses for pharmacy students (DeDombal et al. 1971; Kotzan 1971; Hoffer 1973).

The programs that were designed and developed for this project, were written in PILOT language and utilized Datapoint minicomputers. Four programs of approximately 20 to 30 minutes duration were designed using a case history clinical simulation format. The programs began with a general introduction of the patient and clinical setting and then proceeded through an interactive series of approximately 10 questions which required decision making and selection of a pharmacologic drug therapy regimen. Additional supplemental data was provided as needed throughout the programs.

The subject matter of the programs ("Narcotic Analgesics," "Gout," "Sedative-Hypnotics," and "Parkinsonism") paralleled lecture material in the course Pharmacology 136. Specific problems of patient compliance and patient therapy data base (the process of accumulating appropriate and sufficient data prior to making a therapeutic decision) were also integrated into each program. The computer programs were designed to record all user responses on a data collection tape.

Questionnaire. A questionnaire format (see Figure 1) was selected as the method of assessing the effects of the computer case histories on the subjects' attitudes. The questionnaire consisted of a list of thirty-six

Figure 1. Student Attitude Questionnaire

In order to help make this course more responsive to student needs we need your co-operation in filling out this questionnaire. The completion of this form is , however, completely optional and will not affect your grade and/or standing in this class.

In order that we may be able to correlate your responses now and later in this quarter we will need your social security number "code". This code has been devised to protect your anonymity and works as follows:

If your social security number is: 5 4 5 - 4 7 - 9 8 6 2
cross out: 5 4 - 4 - 8
and enter: 5 - 7 - 9 6 2

Please enter your social security number "code" in the following blanks: X X _ - X _ - X _ _

The following questionnaire consists of a list of 36 items which you are to rate on a scale of form 1 (not important) to 5 (important) in relation to the following 3 variables:

A) Yourself as a future pharmacy practicioner B) Your overall pharmacy education C) This course

Item		Rating not (important) 1	2	3	4	(important) 5
lions		ABC				
drug abuse	1					
medication dosage forms	2					
homework	3					
antiepileptics	4					
cocaine	5					
patient compliance	6					
pain	7					
patient variability	8					
mental disorders	9					
non-drug therapy	10					
bioavailability	11					
electroconvulsive therapy	12					

Item		Rating not (important) 1	2	3	4	(important) 5
getting an A grade		A		B		C
psychiatric therapy (non drug)	13					
drug side effects	14					
tranquilizers	15					
medical ethics	16					
bioequivalence	17					
alcoholism	18					
sedative-hypnotics	19					
dose ranges	20					
marihuana	21					
hallucinogens	22					
contraindications	23					
analgesics	24					

Item		Rating not (important) 1	2	3	4	(important) 5
CNS stimulants	25					
patient therapy data base	26					
outside readings	27					
patient education	28					
antitussives	29					
clinical laboratory tests	30					
lectures	31					
local anesthetics	32					
routes of administration	33					
trade names	34					
drug interactions	35					
drug toxicity	36					

items that the subjects were asked to rate on a numerical-verbal scale from one (not important) to five (important) in relation to three variables: (i) themselves as future pharmacists; (ii) their overall pharmacy education; and (iii) Pharmacology 136, the course associated with the computer exercises.

The 36 items on the questionnaire were selected to cover subject matter in Pharmacology 136 and other clinical pharmacy course work. In addition, two of the items were included in order to measure changes in the subjects' attitudes toward patient compliance and patient therapy data base. These last two items were chosen because they were relevent to the students' education (Suveges 1977), they were not formally taught in Pharmacology 136 and they were stressed in each of the computer case history programs.

The 36 items were randomly assigned to the questionnaire form to minimize any bias which might have been caused by the order in in which the items appeared on the questionnaire.

In order to maintain the subjects' anonymity while at the same time identifying the questionnaires so that paired pre- and post-test (first and second questionnaire) results could be analyzed, a social security number code (i.e. XX_-X_-_X__), was used in which the subject merely filled in the five blanks.

Course Evaluation Form. The course evaluation form consisted of seven questions. Three questions were related directly to the computerized case histories. These questions specifically rated the computerized case histories on a scale from one (poor) to five (excellent) and addressed whether or not more such computer-aided instructional programs should be developed and implemented into the curriculum.

Execution of The Experiment. The subjects were randomly assigned, by means of a table of random numbers, to three separate groups. All three groups completed the questionnaire on the first day of class. A second questionnaire was mailed, along with a stamped self-addressed anonymous return envelope and an explanatory cover letter, to respective thirds of the class at 3, 7 and 10 weeks into the quarter. This procedure allowed any differences in ratings between paired first and second questionnaires to be correlated with the number of computerized case histories used and with the course content.

Based upon a survey done the previous year, it was decided to allow the subjects to use the computer exercises individually or in groups. The computer case histories were available to the subjects throughout the fall quarter seven days a week during regular library hours at the self-instructional media area on campus (SIMA). The subjects were asked to go through the case histories at their convenience and were not urged or coerced to participate at any time because it was intended to have this project represent normal student use. On the last day of class the subjects were asked to voluntarily fill out the course evaluation form.

Evaluation And Analysis of The Results. The data were derived from three major sources. The primary data source was the questionnaires that the subjects had completed. Means, standard deviations, correlations, change scores and paired t-tests were calculated on an IBM 370 using The Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975).

The second source of data was the responses that were automatically recorded on the computer data collection tapes as the subjects proceeded through the computer case histories. This provided information concerning the amount of use the subjects made of the computer case histories as well as information that could be used to modify the programs.

The third source of data was the course evaluation form that the subjects completed on the last day of the course. This provided information regarding the student's attitudes towards these computer case histories and the development of future computer case histories.

RESULTS

Questionnaire. Forty-six (out of a possible 90) subjects (51%) completed both first and second questionnaires.

Of the 324 paired means, only 27 (8%) showed statistically significant changes ($P < 0.05$). Table I identifies both the 27 items which changed and the categories in which changes occurred. The changes were almost equally divided among the three different post test groups (41% in group 1; 30% in group 2; and 30% in group 3). Twenty-one of the 27 items (78%) had significant changes in a negative direction. Category C (course-related attitudes) accounted for the majority of attitude changes (52%) with categories A and B accounting for 19% and 30% respectively.

Figures 2 and 3 show the relationship between paired mean change scores (mean score questionnaire No. 2 minus mean score questionnaire No. 1) for items 6 (patient compliance) and 26 (patient therapy data base) and the number of computer case history programs that the subjects completed. These two items were chosen for this kind of analysis because specific examples dealing with patient compliance and patient therapy data base were integrated into each computer case history program. These figures show no significant trend, in either item, for a correlation between use of the computer programs and change scores.

Computer Data Tapes. The computer programs automatically recorded all responses. The responses were stored on a data collection tape in summarized form. This stored information included the computer case history number; the sequence number of the question; and the subjects' response. For example: "2Q3,4" would indicate that the subject chose response 4 to the third question in the second computer case history program.

The response recorded on these automatic data collection tapes indicated that all four of the case history computer exercises had been used: Case History No. 1: 23 times; Case History No. 2: 20 times; Case History No. 3: 10 times; and Case History No. 4: 8 times. An exact number of individual users could not be determined, however as the subjects were allowed

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Table 1. Item numbers and categories which showed significant changes*

		1	2	3
(A)	+	-	-	33
	-	25,32	15,22	-
(B)	+	-	28	-
	-	21,33	3,6,20	25,30
(C)	+	-	12	8,18
	-	4,5,9,16,21,25	7	3,17,30

*Each number in this table identifies an item on the questionnaire for which the post test mean rating differed significantly (P< 0.05) from the pre test rating. Differences are shown as either positive (+) or negative (-) for post test groups 1,2 and 3 in relation to variables: A (future pharmacy practice); B (overall pharmacy education); and C (course pharmacology 136).

Figure 2. Item 6: Patient Compliance

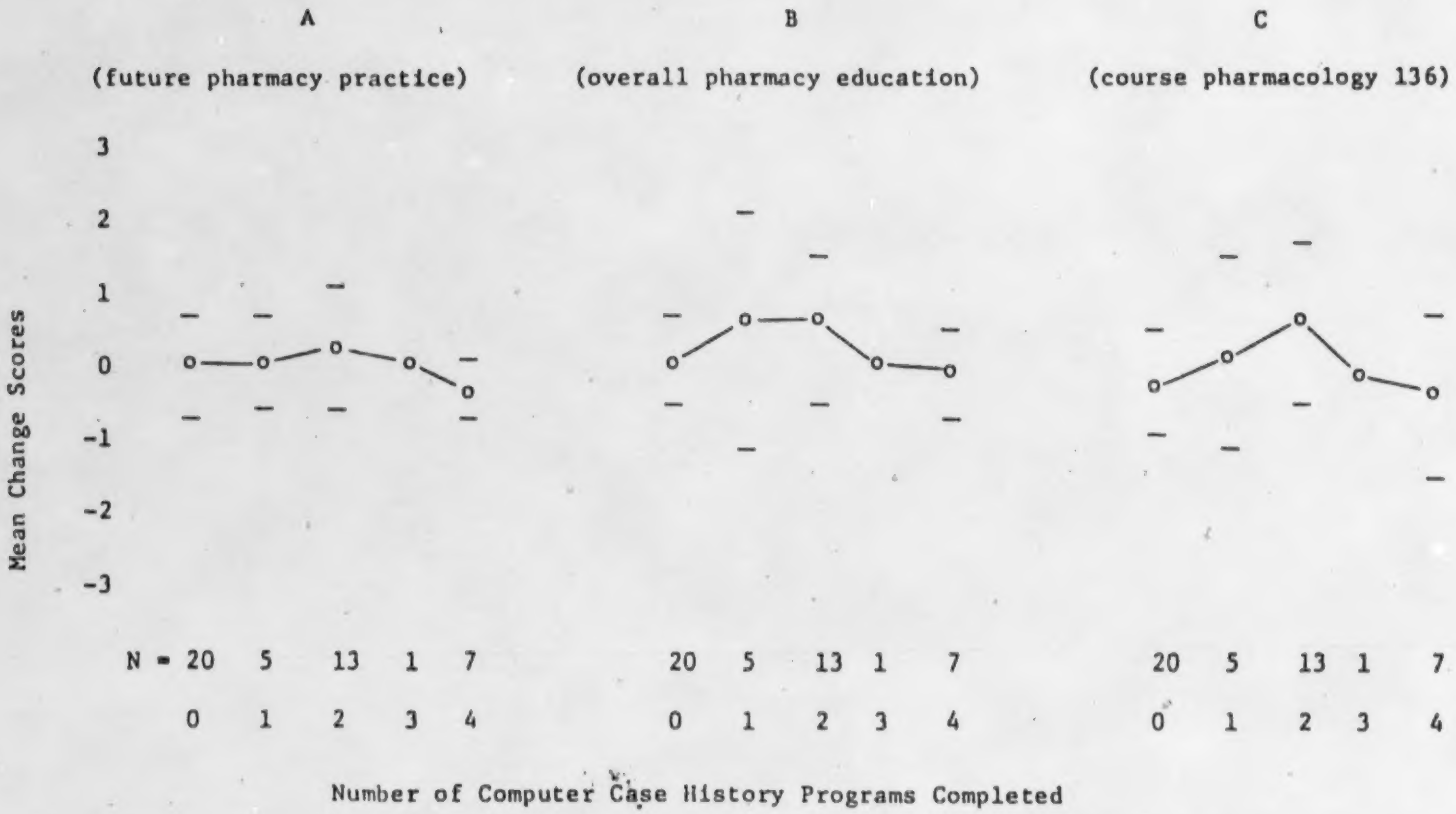

Figure 2. Relationship of Student Attitudes and Use of Computer Case History Programs. Each data point (o) represents the mean difference between pre- and post-test ratings for item #6 of the questionnaire (patient compliance). The horizonta' bars (-) represent 95% confidence intervals and N is the number of subjects.

Figure 3. Item 26: Patient Therapy Data Base

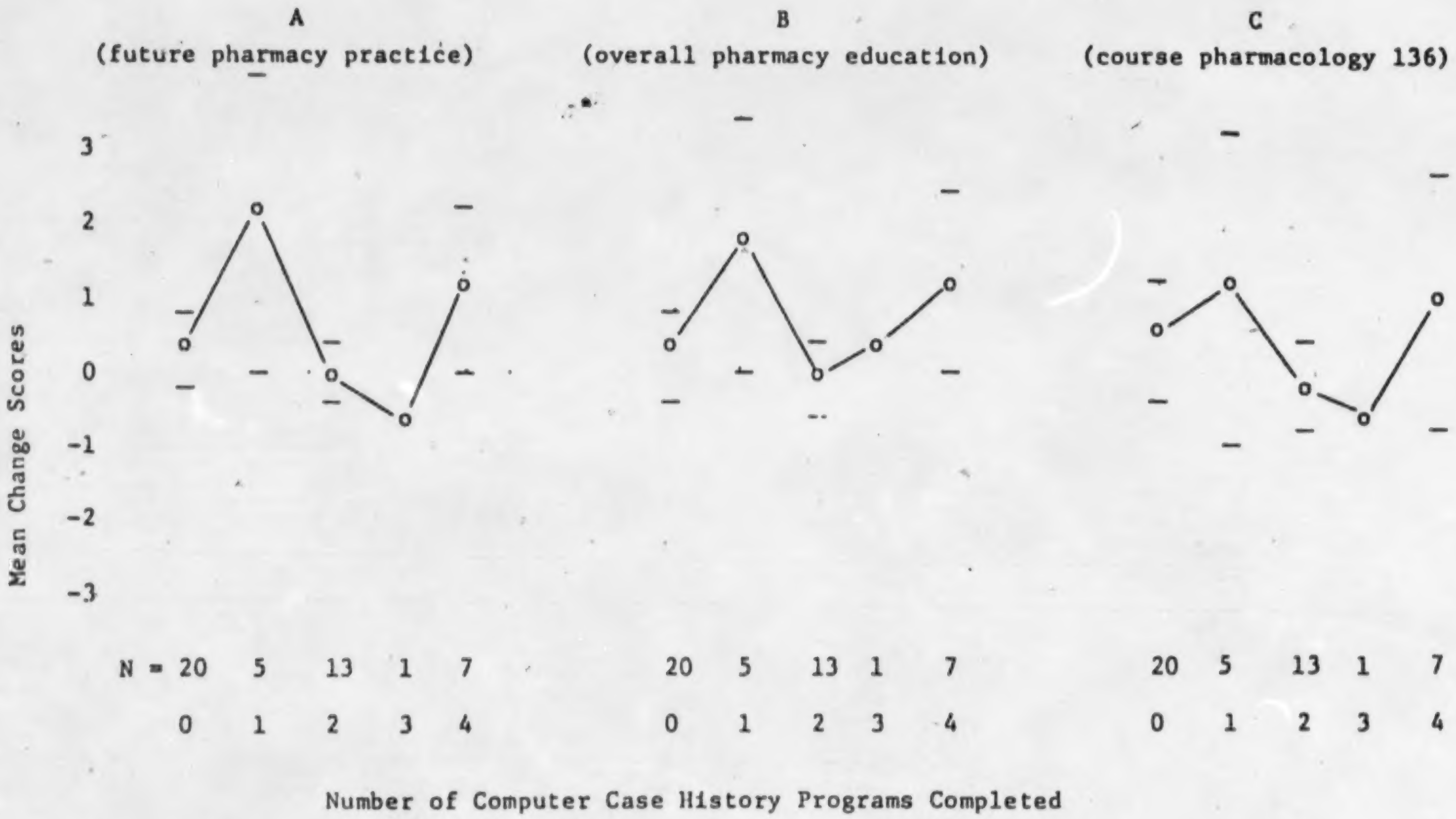

Figure 3. Relationship of Student Attitudes and Use of Computer Case History Programs. Each data point (o) represents the mean difference between pre- and post-test ratings for item #26 (patient therapy data base). The horizontal bars (–) represent 95% confidence intervals and N is the number of subjects.

to go through the computer case histories by themselves or in groups.

Course Evaluation Form. Sixty-eight of 90 students (76%) completed the course evaluation form. Of these 68 subjects, 41 (60%) did not respond to questions about the computer case histories and presumably did not use the computer case history exercises.

Twenty-seven students (40% of those completing the course evaluation form) indicated that they had used one or more of the computer case histories on at least one occasion. These students rated the four programs (Table 2A) on a scale from one (poor) to five (excellent) with an overall mean rating of four for the 4 case histories based upon 60 different ratings. These same students indicated that they would like to see more such self-instructional computer programs developed and used in the curriculum (Table 2B).

DISCUSSION

The results of this study indicate that, although students favored the development and use of more computer-aided instructional programs in pharmacology, student attitudes, as assessed by questionnaire, were not significantly influenced by computer case history usage.

That students gave high ratings to the computer-aided instructional programs was an expected result based on student opinions from surveys done by the pharmacology department in previous years (Burkhalter 1976). However, the result which indicated no correlation between student use of the computer aided instruction programs and student attitudes was not expected.

There are several possible explanations for the lack of a significant change in attitudes in relation to computer case history usage. First, since the computer aided instructional experience was optional and did not bear the onus of grading, and since it was a relatively new and novel educational tool for this group of learners (similar to an audiovisual game), the students may not have taken their participation "seriously" and this may have contributed to the

Table 2A. Course Evaluation Results

Ratings of the Computer Case Histories:

Case History			Number of Responses	Mean Rating
1. Narcotic Analgesics:			0	
	poor	1	0	
		2	0	
	average	3	8	
		4	10	
	excellent	5	5	
			Total =23	3.9
2. Gout:				
	poor	1	0	
		2	1	
	average	3	4	
		4	12	
	excellent	5	4	
			Total =21	3.9
3. Sedative-Hypnotics:				
	poor	1	0	
		2	0	
	average	3	1	
		4	4	
	excellent	5	4	
			Total = 9	4.3
4. Parkinsonism:				
	poor	1	0	
		2	0	
	average	3	0	
		4	3	
	excellent	5	4	
			Total = 7	4.6

Table 2B. Course Evaluation Form Results

In Favor of using more such computer case histories:

Response	Number of Responses	Percentage
1. Blank (no response)	2	7
2. No Opinion	0	0
3. Yes	25	93
4. No	0	0

stability of attitudes. Second, and along the same line of thought, is the possibility that the duration and intensity of exposure to the computer aided instructional programs was not sufficient to induce attitudinal changes in the students. In relation to this possible explanation, it is interesting to note that the attitudes examined by this projects' questionnaire seemed very stable over time during the Fall quarter of this project. The few instances in which pre- and post test differences were statistically significant, (8%) were primarily in the course related category (4.3%). It would be expected that as students proceed through a course their perception of the items important to the course would increase and this may account for the majority of course-related attitude changes that were observed. Individual item changes in attitudes, however, could not be associated with any specific influences (eg., lectures, laboratories or computer aided instructional programs) and may have been due to chance alone.

Another possibility is that the questionnaire was not adequately designed to measure changes in student attitudes. Both the wording and construction of the questionnaire were based upon educational research guidelines (Gage 1963; Nunnally 1970; Finkbeiner 1973; Simpson and Koenig 1975) in order to insure that the questionnaire would meet the study requirements of measuring changes in attitudes. Supporting the validity of the questionnaire is an analysis of the C category (relationship to course) post test ratings. Course related items were rated much higher (mean = 4.0) than non-course items (mean = 2.8). It was expected that students could distinguish between course and non-course items at the end of the quarter and these results show that this distinction was measured by the questionnaire.

Another explanation is based upon the relatively low number of students who participated in this project. The number was much lower than anticipated, based on previous surveys of student interest in computer aided instructional programs in pharmacology (Burkhalter 1976). Only 46 out of 90 students (51%) completed the pre- and post tests (first and second questionnaires). It should be noted that the students had an extremely heavy clinical pharmacy course load during the Fall quarter of this project. As one study points out (Davis and Heller 1976), when student class and study demands exceed 60 hours per week the students cut back somewhere and in this case the new and voluntary participation with the computer aided programs would be a likely candidate to be cut back. The small number of students in each sample group, as a result of the low participation, increases the difficulty of obtaining statistically significant differences. In addition, it is also possible that the character traits, learning abilities, etc., of the students who chose not to participate may be significantly different from those students who did participate and thus the results may have been different had all the students participated in this project.

Another possible explanation for the results is the high mean pre-test ratings which the students assigned to the items "patient compliance" and "patient therapy data base". The non-course pre test ratings for these items were approximately four (on a scale from one to five). Thus, the subjects already perceived these as important items prior to the initiation of this experiment and the possibility of obtaining a significantly higher post-test rating was very low.

An extensive literature search revealed no similar studies undertaken in the subject area of pharmacology with which the results of this study and the possible interpretations could be compared. Thus, no additional support or detraction can be made for any particular interpretation of the results as presented here.

In summary, although users rated the computer case histories highly there was no observed correlation between the number of computer case histories used and changes in student attitude as measured by a questionnaire.

The limited data available suggest that computer case history usage did not significantly affect student attitudes. The data also suggest that the attitudes measured were not significantly changed by any events (i.e., Pharmacology 136, other courses, etc) that transpired during the fall quarter of this project.

Based upon experience gained in this study, the following recommendations are made. First, evaluation of computer-aided instruction should be done in segments of the curriculum where the demands upon student time are not overwhelming. Second, in order to assure adequate generation of data, maximal student usage of computer aided instructional material should be insured by making participation mandatory. Third, assurance must be made that the instrument used for measuring changes in attitudes or learning is appropriate and can actually detect changes if they occur. Fourth, that a pilot study be performed on a small random sample of the proposed population of subjects.

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